National TDA-SAP Report: Thailand

Implementing the Strategic Action Programme for the South China Sea and Gulf of Thailand (SCS SAP) Project

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Preface

The UNEP/GEF "Implementing the Strategic Action Programme for the South China Sea and Gulf of Thailand" (SCS-SAP) Project was initiated to assist participating countries in meeting the targets of the approved Strategic Action Programme (SAP) for the marine and coastal environment. Executed by the United Nations Office for Project Services (UNOPS), the project is a partnership between the Ministries responsible for the environment in Cambodia, China, Indonesia, Philippines, Thailand, and Vietnam. The SCS-SAP commenced in 2018 and will be implemented until 2026, supported by USD 15 million in funding from the GEF and co-financing of USD 81 million from participating countries.

The project works in synergy with its sister project, the UNEP/GEF "Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and Gulf of Thailand," executed by SEAFDEC. Together, these initiatives aim to improve the management of fisheries and critical marine habitat linkages. Full implementation of the SCS-SAP began in July 2021, focusing on three key components:

- **Component 1:** Reducing habitat degradation and loss via national and local reforms to achieve SAP targets for coastal habitat management.
- **Component 2:** Strengthening knowledge-based action planning for the management of coastal habitats and land-based pollution.
- **Component 3:** Facilitating regional and national level integration and cooperation for the implementation of the SAP.

In Thailand, the Department of Marine and Coastal Resources (DMCR) of the Ministry of Natural Resources and Environment serves as the national lead and implementing agency. Supported by Regional and National Expert teams—including governmental and academic partners from the Department of Fisheries, the Pollution Control Department, Ramkhamhaeng University, and Kasetsart University—the project is currently undertaking a critical update of the Transboundary Diagnostic Analysis (TDA) and Strategic Action Programme (SAP).

This document, the **National Transboundary Diagnostic Analysis (TDA) for Thailand**, represents a fundamental process for assessing and managing aquatic ecosystems. As the Large Marine Ecosystems (LMEs) of the South China Sea and the Gulf of Thailand are critical for biodiversity and millions of livelihoods, effective management is essential. Building upon the previous regional analysis undertaken in 2000 (Talaue-McManus), this report updates the diagnostic analysis of environmental problems to guide the next phase of strategic action.

The assessment results presented herein are organized to identify transboundary environmental problems, analyze their root causes and impacts, and prioritize actions with potential global and national benefits. The report is structured as follows:

1. **Status of the Marine Environment:** An update on the physical and biological status of the Gulf of Thailand and South China Sea coastal zones.
2. **Causal Chain Analysis:** A detailed examination of the root causes linking socio-economic drivers to environmental degradation.
3. **Governance Analysis:** An assessment of the legal and institutional frameworks supporting marine resource management in Thailand.
4. **Priority Actions:** Recommendations for national reforms to support the regional Strategic Action Programme.

This National TDA serves as a key output of the SCS-SAP Project, providing the scientific and technical baseline required to facilitate sustainable resource management and strengthen regional coordination.

Acronyms

Acronym	Definition	Acronym	Definition
ACB	ASEAN Centre for Biodiversity	JABBA	Just Another Bayesian Biomass Assessment
ACCPP	ASEAN Conference on Combatting Plastic Pollution	LB-SPR	Length-Based Spawning Potential Ratio
ADB	Asian Development Bank	LEG	Low Efficiency Gear
ALDFG	Abandoned, Lost, or otherwise Discarded Fishing Gear	MARPOL	International Convention for the Prevention of Pollution from Ships
AMAF	ASEAN Ministers on Agriculture and Forestry	MCS	Monitoring, Control, and Surveillance
AN-IUU	ASEAN Network for Combating IUU Fishing	MD	Marine Department
APEC	Asia-Pacific Economic Cooperation	MFA	Ministry of Foreign Affairs
ASEAN	Association of Southeast Asian Nations	MIP	National Maritime Interests Protection Policy Committee
BBNJ	Biodiversity Beyond National Jurisdiction	MONRE	Ministry of Natural Resources and Environment
BCG	Bio-Circular-Green Economy	MPA	Marine Protected Area
BMSY	Biomass at Maximum Sustainable Yield	MSP	Marine Spatial Planning
BOI	Board of Investment	MSY	Maximum Sustainable Yield
BOD	Biochemical Oxygen Demand	MTI	Marine Trophic Index
BTR	Biennial Transparency Report	MWQI	Marine Water Quality Index
CAGR	Compound Annual Growth Rate	NAP	National Action Plan / National Adaptation Plan
CBD	Convention on Biological Diversity	NBC	National Biodiversity Conservation Committee
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora	NBSAP	National Biodiversity Strategy and Action Plan
CMS	Convention on Migratory Species	NbS	Nature-based Solutions
COBSEA	Coordinating Body on the Seas of East Asia	NC	National Communication (UNFCCC)
COD	Chemical Oxygen Demand	NCCP	National Climate Change Policy Committee
CPUE	Catch Per Unit Effort	NCS	Natural Climate Solutions
CR	Critically Endangered (IUCN status)	NDC	Nationally Determined Contribution
CRI	Composite Risk Index	NEA	National Environmental Assessment
CSO	Civil Society Organization	NEB	National Environment Board
CSR	Corporate Social Responsibility	NESDC	Office of the National Economic and Social Development Council
DASTA	Designated Areas for Sustainable Tourism Administration	NESDP	National Economic and Social Development Plan
DBD	Department of Business Development	NFC	National Fisheries Committee
DCCE	Department of Climate Change and Environment	NGO	Non-Governmental Organization
DG-MARE	Directorate-General for Maritime Affairs and Fisheries	NMCRC	National Marine and Coastal Resources Committee
DIW	Department of Industrial Works	NPC	National Park Committees / National Pollution Control Committee
DMCR	Department of Marine and Coastal Resources	NT	Near Threatened (IUCN status)

DMF	Department of Mineral Fuels	OECM	Other Effective Area-based Conservation Measures
DNP	Department of National Parks, Wildlife and Plant Conservation	ONEP	Office of Natural Resources and Environmental Policy and Planning
DO	Dissolved Oxygen	ONSC	Office of the National Security Council
DOF	Department of Fisheries	OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation
DOPA	Department of Provincial Administration	PCD	Pollution Control Department
DoT	Department of Tourism	PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
DPSIR	Driver-Pressure-State-Impact-Response (framework)	PES	Payment for Ecosystem Services
DPWTC	Department of Public Works and Town & Country Planning	PI	Pressure Index
EAFM	Ecosystem Approach to Fisheries Management	PMUC	Program Management Unit for Competitiveness
EBM	Ecosystem-Based Management	PPP	Public-Private Partnership
EbA	Ecosystem-based Adaptation	PPR	Primary Production Required
EEC	Eastern Economic Corridor	RAP	Regional Action Plan
EEA	European Environment Agency	RAP MALI	Regional Action Plan on Marine Litter
EEZ	Exclusive Economic Zone	RCP	Representative Concentration Pathway
EIA	Environmental Impact Assessment	RID	Royal Irrigation Department
EM-DAT	Emergency Events Database	RPOA-IUU	Regional Plan of Action to Promote Responsible Fishing Practices Including Combating IUU Fishing in the Region
EMSY	Fishing Effort at Maximum Sustainable Yield	RTN	Royal Thai Navy
EN	Endangered (IUCN status)	SAP	Strategic Action Programme
EnLAW	Environmental Litigation and Advocacy for the Wants	SCS	South China Sea
EPI	Environmental Performance Index	SDF	Sustainable Development Foundation
EPR	Extended Producer Responsibility	SDG	Sustainable Development Goal
E-READI	Enhanced Regional EU-ASEAN Dialogue Instrument	SEA-MaP	Southeast Asia Regional Program on Combating Marine Plastics
F	Fishing Mortality	SEAFDEC	Southeast Asian Fisheries Development Center
FAO	Food and Agriculture Organization of the United Nations	SEP	Sufficiency Economy Philosophy
FDI	Foreign Direct Investment	SLR	Sea Level Rise
FMSY	Fishing Mortality at Maximum Sustainable Yield	SSB	Spawning Stock Biomass
GBF	Kunming-Montreal Global Biodiversity Framework	SSF	Small-Scale Fisheries
GCF	Green Climate Fund	SSOM	Special Senior Officials Meeting
GDP	Gross Domestic Product	SWG	Scientific Working Group
GEF	Global Environment Facility	TAC	Total Allowable Catch
GHG	Greenhouse Gas	TDA	Transboundary Diagnostic Analysis
GNI	Gross National Income	TDRI	Thailand Development

			Research Institute
GoTFish	Promoting the Blue Economy and Strengthening Fisheries Governance of the Gulf of Thailand through the Ecosystem Approach to Fisheries	TEV	Total Economic Value
GPP	Gross Provincial Product	THB	Thai Baht
GT	Gross Tonnage	TMD	Thai Meteorological Department
HDI	Human Development Index	TRF	Thailand Research Fund
HEG	High Efficiency Gear	TSRI	Thailand Science Research and Innovation
ICM	Integrated Coastal Management	TWAP	Transboundary Waters Assessment Programme
IHDI	Inequality-adjusted Human Development Index	UN	United Nations
INFOFISH	Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region	UNCCD	United Nations Convention to Combat Desertification
IOC	Intergovernmental Oceanographic Commission	UNCLOS	United Nations Convention on the Law of the Sea
IOI	International Ocean Institute	UNDP	United Nations Development Programme
IORA	Indian Ocean Rim Association	UNEP	United Nations Environment Programme
IOSEA	Indian Ocean - South-East Asian (Marine Turtle MoU)	UNESCO	United Nations Educational, Scientific and Cultural Organization
IOTC	Indian Ocean Tuna Commission	UNFCCC	United Nations Framework Convention on Climate Change
IPOA-IUU	International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing	USD	United States Dollar
IPPU	Industrial Processes and Product Use	VI	Vulnerability Index
IUCN	International Union for Conservation of Nature	VNR	Voluntary National Review
IUU	Illegal, Unreported, and Unregulated (fishing)	VU	Vulnerable (IUCN status)
		WEEE	Waste from Electrical and Electronic Equipment
		WESTPAC	IOC Sub-Commission for the Western Pacific
		YPR	Yield-Per-Recruit

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Executive Summary

Introduction and Strategic Context

The 2025 National Transboundary Diagnostic Analysis (TDA) establishes a scientifically robust baseline for the marine and coastal environment of the Gulf of Thailand (GoT). This report updates the seminal Year 2000 assessment, shifting focus from historical resource extraction issues to complex "cumulative" and "transboundary" threats, including marine plastic debris, climate-induced coral bleaching, and hazardous industrial waste from the Eastern Economic Corridor (EEC).

Serving as Thailand’s contribution to the regional SCS-GOT TDA, this analysis supports compliance with key international commitments, including SDG 14 (Life Below Water), the Kunming-Montreal Global Biodiversity Framework (Target 3: 30x30), and the COBSEA Regional Action Plan on Marine Litter. The findings provide the evidence base necessary for formulating the next National Action Plans (NAPs) and guiding investment into the "Blue Economy" and coastal resilience.

Assessment Methodology

The TDA employs a multi-scalar, indicator-based integrated assessment framework to move beyond simple inventorying toward holistic risk analysis.

- Conceptual Frameworks: The assessment utilizes the "Concentric Circles of Risk" to map anthropogenic drivers against ecosystem health and the DPSIR (Driver-Pressure-State-Impact-Response) framework for socio-economic analysis.

- Geographic Scope: Analysis was conducted at the national scale, provincial scale (17 coastal provinces), and focal site scale (five sites: Welu River Estuary, Bandon Bay, Pak Phanang Bay, Samut Prakan Coast, and Don Hoi Lot).

- Thematic Modeling:
  - Socio-economics: A Composite Risk Index (CRI) quantifying "Pressure" and "Vulnerability".
  - Fisheries: Fox Surplus Production and JABBA (Bayesian) models to estimate Maximum Sustainable Yield (MSY) and biomass depletion.
  - Pollution: Marine Water Quality Index (MWQI) and mass-balance waste flow analysis.
  - Governance: TWAP Architecture Assessment to evaluate institutional completeness and integration.

Risk Assessment

The assessment reveals that risks are not evenly distributed across the 17 coastal provinces. The Composite Risk Index (CRI) classifies provinces into three critical typologies requiring differentiated policy responses:

- Pure Intensity Risk (Hotspots): Provinces like Bangkok and Samut Songkhram face highly concentrated pressures within limited land areas, driven by urbanization and industrial activity.

- Pure Magnitude Risk (Portfolio): Provinces such as Phetchaburi and Songkhla rank high in magnitude due to their extensive geography, increasing the aggregate exposure of resources and communities.

- Hybrid Risk (Double Burden): Surat Thani faces the most complex scenario, ranking high in both intensity and magnitude, requiring integrated spatial management and large-scale resource planning.

- Climate as a Multiplier: Hydrometeorological hazards amplify these vulnerabilities. Between 2000 and 2024, tropical cyclones caused significant volatility, with damages peaking at USD 904 million in 2024, confirming the fragility of coastal zones.

Key Findings by Thematic Area

1) Socioeconomicss and Climate-Related Threats
The assessment highlights that Socioeconomics vulnerabilities are deeply intertwined with specific geographic and climate risks:

- Inequality and Livelihood Traps: A stark development gap persists between regions. While industrial hubs in the Upper Gulf (e.g., Rayong, Chon Buri) exhibit high urbanization and dramatic poverty reduction, the Deep South (e.g., Pattani, Narathiwat) remains rural and trapped in persistent poverty. This creates a "livelihood trap" where the poorest communities are most dependent on the climate-sensitive resources currently under threat.

- Risk Amplification: Climate hazards act as a "multiplier" that intensifies these existing vulnerabilities. National data confirms that hydrometeorological hazards (cyclones, erosion) significantly amplify risks for coastal provinces, with fatality spikes recorded in volatile years like 2024 (45 deaths).

- Urbanization Pressure: The Upper Gulf forms a primary urban corridor (Bangkok to EEC) with extreme population densities (up to 3,562 persons/km² in Bangkok), creating intense land-use pressure that contrasts sharply with the rural lower Gulf.

2) Land Based Pollution and Marine Pollution
- Waste Management Gap: Thailand generates ~27.2 million tonnes of municipal solid waste annually, but only 38% is properly disposed of. Approximately 4.73 million tonnes (17%) are improperly managed, leading to significant plastic leakage into the Gulf.

- Wastewater Crisis: A critical infrastructure gap exists, with 59% of domestic wastewater remaining untreated, contributing to seasonal eutrophication in the Upper Gulf.

- Industrial Risks: Rapid expansion in the EEC has concentrated hazardous waste risks (1.63 million tons generated annually), necessitating stricter enforcement in Rayong, Chonburi, and Samut Prakan.

3) Coastal Ecosystems

- Condition Contrast: Offshore reefs (e.g., Koh Losin) remain healthy with ~70% live coral cover, acting as critical larval sources. In contrast, nearshore reefs (e.g., Koh Si Chang) are degraded (29% cover) by sedimentation and pollution.

- Blue Carbon Assets: Mangroves and seagrasses are vital carbon sinks, storing 0.25–2 million tonnes of carbon per focal site. However, seagrass meadows (e.g., Bandon Bay) face fragmentation from aquaculture and turbidity.

- Economic Value: The ecosystem services of the five focal sites alone are valued between USD 17–32 million per site annually.

4) Fisheries

- Stock Recovery: Following the 2015 legal reforms, the sector has transitioned from collapse to stabilization. Catch Per Unit Effort (CPUE) recovered from a low of 14.69 kg/hr (2013) to 21.52 kg/hr (2023).

- Biomass Status: Current assessments indicate that the biomass of demersal, pelagic, and anchovy groups is now above the level producing MSY ($B > B_{MSY}$).

- Persistent Issues: Challenges remain regarding the high catch of juvenile "trash fish" by trawlers and "effort creep" (increased efficiency despite fishing day limits).

5) Governance

- Structural Gaps: While Thailand has a strong legal framework (e.g., 2015 Marine Coastal Act), a significant "implementation gap" persists at the provincial level due to weak sectoral integration and budget constraints.

- Economic Disparity: High-income EEC provinces possess strong fiscal capacity for management, while resource-dependent provinces in the Deep South lack the funds for effective conservation, creating unequal governance outcomes.

Recommended Priority Actions

To address these challenges, the TDA outlines a strategic roadmap shifting from reactive to proactive governance:

1) Mainstream Proactive Risk Governance: Shift national budgeting from post-disaster relief to pre-disaster mitigation. Apply risk assessment models (like CRI)

to justify preventative investments in provincial plans.

2) Implement Area-Based Adaptation:
   - *Intensity Zones:* Enforce climate-proofing for infrastructure in urban hubs.
   - *Magnitude Zones:* Invest in large-scale Ecosystem-based Adaptation (EbA) like mangrove restoration.

3) Enhance Regional Cooperation:
   - *Pollution:* Harmonize monitoring protocols and implement Extended Producer Responsibility (EPR) schemes under ASEAN/COBSEA frameworks.
   - *Fisheries:* Establish joint management plans and regional Total Allowable Catch (TAC) for transboundary species like neritic tunas and mackerel.

4) Strengthen Ecosystem Management: Accelerate the transition to Ecosystem-Based Management (EBM) by scaling up "Blue Carbon" financing and resolving legal contradictions regarding by-catch and gear selectivity.

5) Governance Integration: Finalize the Climate Change Act to provide a binding legal framework and improve cross-sectoral coordination between the DMCR, key ministries, and provincial authorities.

I. Introduction

1.1 Aims of national report

The primary aim of this National Transboundary Diagnostic Analysis (TDA) is to provide a scientifically robust, holistic assessment of the state of the marine and coastal environment in the Gulf of Thailand. This report serves as the fundamental baseline for identifying, quantifying, and prioritizing environmental problems that are transboundary in nature or have significant national implications.

Specifically, this report aims to:

1) **Diagnose the State of the Environment:** Consolidate data on the status of key coastal habitats (mangroves, coral reefs, seagrass, and wetlands), fisheries stocks, and water quality to establish a clear 2024–2025 baseline.
2) **Identify Root Causes:** Analyze the causal chains linking environmental degradation—such as eutrophication in the Upper Gulf or coral bleaching events—to their immediate and root causes, including socio-economic drivers like industrialization in the Eastern Economic Corridor (EEC) and agricultural runoff.
3) **Assess Governance Architectures:** Evaluate the effectiveness of current institutional arrangements, legal frameworks, and financial mechanisms (such as the budgets of the DMCR, DOF, and DNP) in managing these resources.
4) **Prioritize Action:** Provide the evidence base necessary for formulating the National Action Plans (NAPs) and guiding investment into "blue economy" initiatives, ecosystem restoration, and pollution control.

1.1.1 Inputs to the SCS-GOT TDA

This National TDA constitutes Thailand's specific contribution to the regional **Transboundary Diagnostic Analysis for the South China Sea and Gulf of Thailand (SCS-GOT TDA)**. As the Gulf of Thailand is a semi-enclosed sea connected to the South China Sea, the environmental dynamics within Thai waters—including nutrient loads, fish stock migration, and marine debris transport—have direct transboundary implications for neighboring riparian states (Cambodia, Vietnam, and Malaysia).

The inputs from this national report to the regional SCS-GOT TDA framework include:

- **Fisheries Data:** Providing catch reconstruction data and Catch Per Unit Effort (CPUE) trends for the Gulf of Thailand, which helps assess the status of shared transboundary fish stocks and the efficacy of effort control measures (e.g., "Fishing Days" limits).
- **Pollution Hotspots:** Identifying land-based pollution sources, specifically

nutrient loading from major river systems (Chao Phraya, Tha Chin) and plastic leakage, which contribute to regional eutrophication and marine litter problems addressed by mechanisms like COBSEA.

- **Habitat Status:** Contributing data on the extent and health of critical habitats—such as the 255.7 km² mangrove complex in Bandon Bay and the "Larval Source" coral reefs at Koh Losin—which are essential for maintaining regional biodiversity connectivity and genetic refugia.
- **Climate Vulnerability:** Sharing assessments of climate impacts, such as sea-level rise and coral bleaching, to inform regional adaptation strategies.

1.1.2 Analysis to help national reporting to SDG and other international commitments

The data and analysis generated in this National TDA are designed to directly support Thailand's monitoring and reporting obligations under key global and regional frameworks. By harmonizing national indicators with international metrics, this report facilitates compliance with the following commitments:

1) UN Sustainable Development Goals (SDGs):

- **SDG 14 (Life Below Water):** The report's assessment of marine pollution (Indicator 14.1), ecosystem management (Indicator 14.2), and fisheries sustainability (Indicator 14.4) provides the necessary data for Voluntary National Reviews (VNRs).
- **SDG 13 (Climate Action):** The quantification of "Blue Carbon" stocks in mangroves and seagrass beds (e.g., carbon storage estimates for Bandon Bay and Chumphon) directly supports Thailand's climate action reporting.

2) The Kunming-Montreal Global Biodiversity Framework (GBF):

Target 3 (30x30): The evaluation of Marine Protected Areas (MPAs) and Other Effective Area-based Conservation Measures (OECMs), such as the preservation of Koh Losin and underwater pinnacles, supports tracking progress toward protecting 30% of marine areas by 2030.

3) Nationally Determined Contributions (NDCs) under the Paris Agreement:

Climate Vulnerability and Socio-Economic Resilience: The report integrates climate impact assessments with socioeconomic data to inform National Adaptation Plans. It highlights the acute vulnerability of the 18.6 million residents in the Gulf of Thailand's coastal provinces (2020), particularly in high-density provinces like Bangkok (3,562 persons/km^2) and Samut Prakan (1,346 persons/km²). It further analyzes economic exposure, noting that the 2024 cyclone season alone caused estimated damages of USD 904 million. By correlating poverty rates with climate risks, the analysis identifies populations with low adaptive capacity, ensuring that adaptation strategies prioritize the most vulnerable communities dependent on climate-sensitive sectors like fisheries and tourism.

4) **Regional and Specific Conventions:**

- **Marine Litter:** Supports the *COBSEA Regional Action Plan on Marine Litter (RAP MALI)* by quantifying land-based plastic leakage, monitoring microplastics, and addressing sea-based sources such as Abandoned, Lost, or otherwise Discarded Fishing Gear (ALDFG). In addition, supports the *ASEAN Regional Action Plan for Combating Marine Debris* by quantifying plastic leakage and identifying hotspot areas.
- **Marine Ecosystems:** Supports the COBSEA Marine and Coastal Ecosystems (MCE) Framework by aligning national initiatives on Marine Spatial Planning (MSP) and "Blue Carbon" habitat restoration (mangroves and seagrasses) with regional Sustainable Blue Economy goals and the "30x30" protection targets.
- **Biodiversity Protection:** Provides status updates for species listed under *CITES and the Convention on Migratory Species (CMS),* specifically regarding the Dugong MOU and IOSEA Marine Turtle MOU.
- **BBNJ Agreement:** The governance analysis prepares Thailand for future engagement in the *Biodiversity Beyond National Jurisdiction (BBNJ)* framework by assessing national capacity for high-seas governance.

1.2 Major water related environmental problems

A comparative analysis between the seminal Year 2000 National TDA and the current 2025 assessment reveals a profound shift in the scale and complexity of Thailand's water-related challenges. In 2000, the primary concerns were driven by unchecked resource extraction (mangrove deforestation for shrimp farming) and basic sanitation failures (untreated domestic sewage). By 2025, while legacy issues persist, the landscape is dominated by "cumulative" and "transboundary" threats, including marine plastic debris, climate-induced coral bleaching, and hazardous industrial waste from the Eastern Economic Corridor (EEC).

The following table summarizes the evolution of these environmental priorities over the past 25 years.

Table 1.1 Comparative Assessment of Major Water-Related Environmental Problems (2000 vs 2025)

Environmental Issue	Year 2000 Status & Priority	Year 2025 Status & Priority	Trend & Strategic Shift
1. Freshwater Shortage & Management	**High Priority:** Acute shortages due to deforestation and conflict between agriculture and golf courses. Lack of "user pay" systems.	**Medium-High Priority:** Shift to "Water Security" for the EEC industrial hub. Climate-driven droughts remain a threat, but focus has moved to	**From Local Scarcity to Strategic Allocation:** Emphasis is now on securing water for high-value economic zones

		integrated water grid management.	(EEC) amidst climate variability.
2. Marine & Coastal Pollution (Eutrophication)	**High Priority:** Severe eutrophication in Upper Gulf caused by untreated domestic waste and agriculture.	**Critical Priority:** Eutrophication persists in the Upper Gulf (Red Tides). Nutrient loading from agriculture remains high (1.55M tonnes N-fertilizer imported in 2024).	**Persistent & Unresolved:** Basic organic loading remains a core challenge, compounded by denser urbanization in coastal provinces.
3. Marine Debris & Plastics	**Low/Not Prioritized:** Mentioned only as "garbage dumping" or "aesthetic" issues.	**Top Priority (Transboundary):** Thailand ranked among top global contributors. 27.2M tonnes of waste/year with high leakage. Regional focus via COBSEA/ASEAN.	**Emerging Crisis:** Plastic pollution has escalated from a local nuisance to a global transboundary priority requiring circular economy interventions.
4. Fisheries Resources	**Critical Priority:** "Over-exploitation" and "Open Access" regime. Collapse of CPUE to ~14 kg/hr.	**High Priority (Stabilization):** Fleet frozen/reduced; CPUE stabilized (~21 kg/hr in 2023). Focus on IUU combat and "Trash Fish" reduction.	**From Expansion to Control:** Shift from increasing catch volume to effort control (Fishing Days) and combatting IUU fishing.
5. Mangrove Ecosystems	**Critical Priority:** Rapid, widespread destruction (60% loss) driven by intensive shrimp aquaculture conversion.	**Medium Priority (Restoration):** Deforestation halted; focus shifted to "Blue Carbon" restoration. Area stabilized at ~2,613 km² (wetlands).	**From Destruction to Valuation:** Mangroves are now valued assets for carbon credits and coastal defense rather than land for conversion.
6. Coral Reefs	**High Priority:** Physical destruction (dynamite, anchors)	**High Priority (Climate):** Mass bleaching events	**From Local Damage to Global Threat:** Local

	and sedimentation.	(2010, 2016, 2024) are the primary threat. Nearshore reefs degraded (29% live cover) by tourism/sediment.	protection is insufficient against thermal stress; focus is on "Resilience" and "Super Corals".
7. Hazardous/Industrial Waste	**Medium Priority:** Localized contamination (heavy metals) in Samut Prakan.	**High Priority:** Concentrated risk in the EEC (Rayong/Chonburi). 1.63M tonnes of hazardous waste/year.	**Intensification:** The scale of industrial risk has grown exponentially with the EEC development, requiring stricter enforcement.

1.3 Biogeophysical setting

1.3.1 Geomorphology and geological history

The Gulf of Thailand is a shallow, semi-enclosed sea located on the Sunda Shelf, covering an area of approximately 320,000 km² with an average depth of only 45–50 meters and a maximum depth of 85 meters in the central trough. Geologically, the Gulf is defined by a series of Cenozoic rift basins—most notably the Pattani Trough and Malay Basin—which are filled with thick sedimentary sequences (up to 10 km) favorable for hydrocarbon accumulation.

The modern geomorphology of the Gulf is a result of the Holocene marine transgression. During the Last Glacial Maximum (approximately 20,000 years ago), sea levels were roughly 120 meters lower than today, exposing the Sunda Shelf as a vast dry landmass connecting mainland Southeast Asia to Borneo, Sumatra, and Java. The present-day Gulf was then a lowland basin drained by the "Paleo-Chao Phraya" river system, which flowed southeast into the South China Sea. As sea levels rose during the Holocene (reaching a highstand about 4,000–6,000 years ago, approximately 2.5–4 meters above present levels), the shelf was submerged, creating the current marine environment. This recent geological formation means the Gulf acts as a "sediment trap," receiving massive alluvial loads from the Chao Phraya, Tha Chin, Mae Klong, and Bang Pakong rivers, which form a prograding delta in the Upper Gulf.

1.3.2 Climatology, present and projected

The Gulf of Thailand lies within the tropical monsoon zone, governed by two primary wind regimes that drive oceanographic circulation and rainfall patterns.

Present Climate Regime:

- Southwest Monsoon (May–October): Brings warm, moist air from the

Indian Ocean, resulting in the wet season. It drives a general clockwise circulation in the Upper Gulf and influences upwelling along the west coast.

- Northeast Monsoon (November–February): Brings cool, dry air from the Asian continent. This season drives a counter-clockwise circulation and is associated with drier conditions, although heavy rainfall can still occur in the southern peninsula.
- Oceanography: Sea surface temperatures are generally high (28–30°C). Currents are tidal-dominated in nearshore areas, with complex seasonal reversals driven by the monsoons.

Projected Climate Trends (2030–2050):

Climate change modeling under RCP 4.5 and RCP 8.5 scenarios indicates significant shifts for the Gulf region:

- Temperature: Mean annual temperatures are projected to increase by 0.95°C to 3.23°C by the end of the century. By 2050, mean temperatures are expected to rise by approximately 1.5°C.
- Rainfall: Precipitation patterns will become more volatile, with projections suggesting drier winters but more intense rainfall events during the wet season (increasing flood risks).
- Sea Level Rise (SLR): The Upper Gulf is particularly vulnerable due to the synergistic effects of global sea-level rise and local land subsidence (up to 1-2 cm/year in some Bangkok areas). Projections for 2050 estimate a rise of 0.2–0.3 meters, with potential end-of-century rise exceeding 1 meter under high-emission scenarios, threatening coastal megacities and mangrove ecosystems.

1.3.3 Biogeography, endemic and unique marine species

Biogeographically, the Gulf of Thailand belongs to the Sunda Shelf Province within the Indo-West Pacific Realm. This region is a global center of marine biodiversity, yet the Gulf's fauna is geologically young due to the recent Holocene transgression.

Biodiversity and Endemism:

While true deep-evolutionary endemism is limited because the Gulf was dry land until recently, the region supports unique populations and locally adapted species.

- Endemic Invertebrates: *Idiosepius thailandicus* (Thai pygmy squid), discovered in the Gulf, is a notable species found in seagrass and mangrove habitats along the eastern coast.
- Marine Mammals: The Gulf hosts a genetically distinct population of the Irrawaddy Dolphin (*Orcaella brevirostris*). Genetic studies indicate restricted gene flow between the Gulf of Thailand population and those in the Andaman Sea, classifying it as a distinct management unit requiring specific conservation measures
- Fish Diversity: A recent checklist (2023) recorded 131 fish species from

bottom trawls, including new records like the lizardfish *Saurida fortis*. Other key species include the Brownbanded bamboo shark (*Chiloscyllium punctatum*) and the Whale shark (*Rhincodon typus*), which frequents the biodiversity hotspots of Koh Tao and Chumphon pinnacles.

- Mangrove Flora: The Gulf's wetlands harbor critically endangered flora such as *Bruguiera hainesii* and *Sonneratia griffithii*, which are extremely rare globally but found in the Welu River Estuary and other focal sites.

This unique biogeographical setting, combining high productivity with specific genetic refugia, highlights the Gulf's critical role as a "biological pump" for the wider South China Sea ecosystem.

1.4 Assessment Methodology

The methodology employed for the 2025 National TDA represents a significant evolution from previous assessments, moving beyond simple resource inventorying to a holistic, ecosystem-based risk assessment. This transition is necessitated by the increasing complexity of transboundary threats, particularly climate change and marine plastic pollution, which require an integrated analysis of socio-ecological systems.

1.4.1 Conceptual Framework

The assessment adopts a modified **"Concentric Circles of Risk"** framework to conceptualize the relationship between anthropogenic drivers and ecosystem health:

1) **Core (The Ecosystem):** The physical and biological state of coastal resources (e.g., live coral cover, mangrove biomass, water quality). The assessment focuses on "Ecological Integrity" and "Service Provision" (e.g., carbon storage) rather than just extent or quantity.
2) **Inner Circle (Direct Pressures):** Immediate stressors acting on the core, such as nutrient loading from the Chao Phraya River, destructive fishing gear (trawlers), and coastal land conversion.
3) **Middle Circle (Socio-Economic Drivers):** The local and national activities driving the pressures, including the "Blue Economy" sectors (tourism, fisheries), industrialization in the EEC, and urbanization in coastal provinces.
4) **Outer Circle (Global & Regional Forces):** Large-scale, often transboundary drivers such as global climate change (sea-level rise, ocean warming) , global market demand for seafood, and regional plastic waste leakage.

Scale and Scope: The assessment integrates data from local focal sites (micro-scale) up to the national and sub-regional levels (macro-scale), allowing for the identification of "hotspots" where global risks (climate) compound local stressors (pollution).

1.4.2 Subnational Geographic Divisions used in the Analysis

The 2025 TDA refines the geographic scope to focus specifically on the Marine and Coastal Zone of the Gulf of Thailand, departing from the watershed-heavy focus of the Year 2000 report.

- **Administrative Division:** The primary unit of socio-economic analysis comprises the **17 Coastal Provinces** bordering the Gulf of Thailand. These are stratified into three economic clusters: the Industrial Core (Eastern Seaboard), the Developing South, and the Tourism Hubs.
- **Ecological Focal Sites:** To ground-truth the national data, the assessment utilizes five specific "Focal Sites" in the Gulf of Thailand representing distinct ecosystem types and pressure profiles:
  1) **Welu River Estuary (Chanthaburi):** Represents a "Managed Ecosystem" with community forestry.
  2) **Bandon Bay (Surat Thani):** Represents a complex, high-use seascape (aquaculture + carbon sink).
  3) **Pak Phanang Bay (Nakhon Si Thammarat):** Represents an estuary affected by hydrological alteration.
  4) **Samut Prakan Coast:** Represents a "Urban/Industrialized Delta" with extreme pollution stress.
  5) **Don Hoi Lot (Samut Songkhram):** Represents a Ramsar site with unique biodiversity values.

1.4.3 List of Indicators by Component (Comparative Assessment)

The selection of indicators reflects a paradigm shift from "Resource Exploitation" (2000) to "Ecosystem Health and Resilience" (2025).

Table 1.2 Comparative List of Assessment Indicators (2000 vs. 2025)

Component	Year 2000 Indicators (Resource Focus)	Year 2025 Indicators (Resilience Focus)
Fisheries	- Total Catch Volume (Tonnes) - Number of Vessels - CPUE (kg/hr)	- **Catch Composition:** Ratio of "Trash Fish" vs. Commercial Species - **Effort Control:** "Fishing Days" per vessel class - **Stock Health:** Spawning Stock Biomass (SSB) trends

Mangroves	- Total Forest Area (ha) - Rate of Deforestation - Charcoal/Timber Production	- **Blue Carbon Stock:** Soil Organic Carbon (tonnes C/ha) - **Biodiversity:** Species Diversity Indices (Shannon-Wiener) - **Regeneration:** Seedling density and restoration success rate
Coral Reefs	- Percentage of Dead Coral - Physical Damage (Dynamite/Anchors)	- **Live Coral Cover (%)** stratified by depth - **Resilience:** Dominance of stress-tolerant forms (*Porites* spp.) - **Bleaching Response:** Severity and recovery rates
Pollution	- BOD/COD Loads - Coliform Bacteria counts - Heavy Metals (Mercury/Lead)	- **Nutrient Flux:** Nitrogen/Phosphorus loading estimates - **Marine Debris:** Microplastic density (particles/m^3) and composition - **Eutrophication Potential:** Frequency of Red Tides/Algal Blooms
Socio-Economics	- Fishery Income - Water Use Demand	- Demographics: Coastal population, population density - Human wellbeing: Coastal poor, HDI - Economic activities: GDP, fisheries

		contribution to GDP - Climate related threats: Number of tropical cyclones per year, total damage due to tropical cyclones

1.4.4 Assessing Risks to Ecosystems, People, and Livelihoods

The synthesis of these indicators reveals a landscape of compounded risks. The assessment determines risk levels by overlaying **Hazard Exposure** (Pollution/Climate) with **Vulnerability** (Ecosystem Sensitivity/Social Adaptive Capacity).

1) Ecosystem Risk:

- **High Risk:** Nearshore reefs in the Upper Gulf (e.g., Koh Si Chang) and estuaries in Samut Prakan. These areas face a "double burden" of acute land-based pollution (hypoxia, sedimentation) and thermal stress from climate change. The dominance of stress-tolerant species indicates low resilience to future shocks.
- **Moderate Risk:** Mangrove systems in Bandon Bay. While carbon stocks are high, the conversion pressure from aquaculture remains a latent threat, moderated by active community restoration.

2) Socio-Economic and Livelihood Risk:

- **Climate-Poverty Nexus:** The Deep South (Pattani/Narathiwat) is identified as a high-risk zone. High poverty rates (up to 23%) combined with reliance on climate-sensitive small-scale fisheries create a "poverty trap" where resource degradation directly exacerbates social deprivation.
- **Economic Exposure:** The Eastern Economic Corridor (Rayong/Chonburi) faces high *financial* risk. While adaptive capacity is high due to wealth, the sheer value of assets exposed to sea-level rise and storm surges (infrastructure, ports, tourism real estate) poses a significant liability to the national economy.

3. Integrated Governance Implication:

This risk stratification underscores the need for differentiated governance.

- **For High-Risk Ecosystems (Upper Gulf):** Immediate, stringent pollution control (TMDL enforcement) and strict zoning are required to prevent collapse.
- **For High-Risk Livelihoods (Deep South):** Interventions must focus on social safety nets, livelihood diversification, and community-based resource management rather than top-down regulation alone.
- **For Climate Adaptation:** "Blue Carbon" financing mechanisms must be

prioritized to fund the restoration of buffers (mangroves/seagrass) that protect both the wealthy industrial zones and vulnerable coastal communities.

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II. Socioeconomics and Climate-related threats

Abstract

This National Transboundary Diagnostic Analysis (TDA) report evaluates Thailand's current vulnerabilities by examining socioeconomic risks, climate hazards, and the existing policy framework. The analysis employs a Composite Risk Index (CRI), which integrates risk magnitude and intensity metrics to prioritize coastal management efforts. This diagnostic tool categorizes coastal provinces into three distinct groups: 'Pure intensity risk' areas, such as economic hubs requiring targeted spatial management; 'Pure magnitude risk' zones, comprising large provinces that need broad resource planning; and 'Hybrid risk' regions, which score high in both metrics and demand the most integrated policy response. To address these challenges, Thailand relies on an established multi-level policy architecture, extending from the Level 1 National Strategy (2018-2037) and the Level 2 13th National Economic and Social Development Plan down to Level 3 agency-specific mandates, such as the Department of Climate Change and Environment (DCCE) Action Plans. Despite this robust planning, four critical implementation deficiencies remain: strategic gaps arising from poor coordination between economic and climate policies, technical gaps due to scientific uncertainty, operational gaps caused by resource constraints in agencies like the DCCE, and systemic gaps where budgeting prioritizes reactive relief over proactive mitigation. Consequently, shifting from reactive to proactive governance requires reforming the budget structure to favor prevention backed by risk assessment models and implementing differentiated, area-based adaptation tailored to specific risk profiles, such as infrastructure resilience for 'Intensity-risk' areas and ecosystem restoration for 'Magnitude-risk' zones. Finally, strengthening regional cooperation is essential to manage shared threats through upgraded early warning systems and joint climate finance strategies.

Keywords: National Transboundary Diagnostic Analysis (TDA), Composite Risk Index (CRI), Coastal vulnerability

2.1 Key findings

This National TDA report assesses Thailand's current vulnerabilities by analyzing socioeconomic risks, climate hazards, and the policy landscape. The synthesis yields the following key findings:

1. Distinct socioeconomic risk profiles**:** The Composite Risk Index classifies coastal provinces into three priority groups. The 'Pure intensity risk' group covers economic hubs like Bangkok that need targeted spatial management. The 'Pure magnitude risk' group includes large provinces like Surat Thani requiring broad resource planning. Finally, the 'Hybrid risk' group ranks high in both metrics and demands the most integrated policy response.

2. Climate hazards as risk multipliers: Physical threats act as a multiplier that intensifies existing socioeconomic vulnerabilities. National data confirms that hydrometeorological hazards, such as cyclones and erosion, significantly amplify the risks facing coastal provinces.

3. Established policy architecture: Thailand has established a comprehensive multi-level framework to address these challenges. This hierarchy spans from the Level 1 National Strategy (2018-2037) to the Level 2 13th National Economic and Social Development Plan, specifically Milestone 11. It is then operationalized through Level 3 agency-specific frameworks, such as the Action Plans of the Department of Climate Change and Environment.

4. Critical implementation gaps: Despite good planning, four deficiencies hinder progress. Strategic gaps arise from a lack of coordination between economic and climate policies. Technical gaps arise from scientific uncertainty about specific climate impacts. Operational gaps involve resource constraints where agencies like the DCCE face expanded mandates without sufficient budget or staff. Systemic gaps persist due to a budgeting preference for reactive relief over proactive mitigation.

5. Priority actions to transition from reactive to proactive governance: A shift to proactive governance requires three key steps. First, the budget structure must change to prioritize prevention, supported by data from applied risk assessment models. Second, the government needs to implement differentiated, area-based adaptation. This means tailoring responses to specific needs, such as infrastructure resilience for 'Intensity-risk' groups, ecosystem restoration for 'Magnitude-risk' groups, and comprehensive planning for 'Hybrid-risk' areas. Third, regional cooperation must

be strengthened to manage shared threats. Essential measures include upgrading early warning systems, managing marine pollution and oil spills collaboratively, and formulating joint strategies for climate finance.

2.2 Current status by indicator group

2.2.1 Demographic patterns

Thailand has 23 coastal provinces, including Bangkok, stretching along both the Gulf of Thailand and the Andaman Sea, covering a diverse range of ecological, economic, and geographic characteristics **(Figure 2.1)**. Of these, six provinces are situated along the Andaman coast, namely Ranong, Phang-nga, Phuket, Krabi, Trang, and Satun, while seventeen provinces lie along the Gulf of Thailand, including Trat, Chanthaburi, Rayong, Chon Buri, Samut Prakan, Samut Sakhon, Samut Songkhram, Bangkok, Chachoengsao, Phetchaburi, Prachuap Khiri Khan, Chumphon, Surat Thani, Nakhon Si Thammarat, Songkhla, Pattani, and Narathiwat. The province with the longest coastline is Chumphon, extending approximately 248.33 kilometers, whereas Bangkok has the shortest coastline, measuring only 7.11 kilometers.

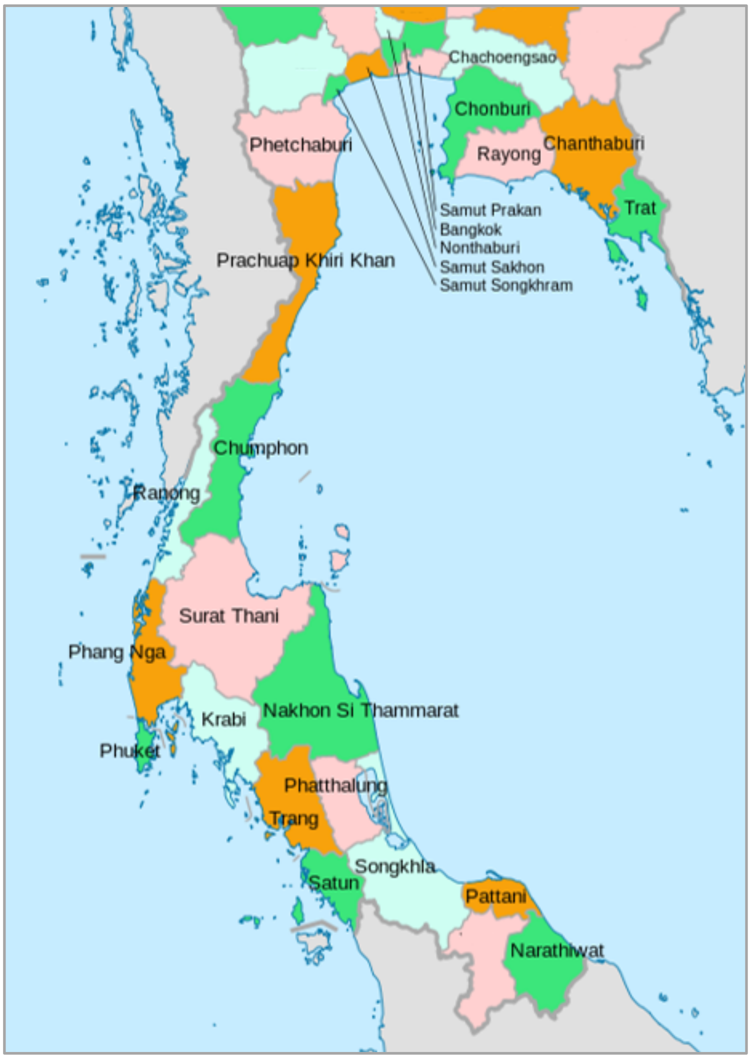


Figure 2.1 The coastal provinces of Thailand

Combined covering 101,647 km² as of 2020, the coastal provinces along the Gulf of Thailand account for 19.8% of the national land area. Provincial sizes vary significantly, ranging from extensive territories like Surat Thani (12,891.5 km², 2.5% of the national total) and Nakhon Si Thammarat (9,942.5 km², 1.9%) to smaller entities such as Samut Songkhram, which occupies only 416.7 km² or 0.08% of the country's total area **(Figure 2.2)**.

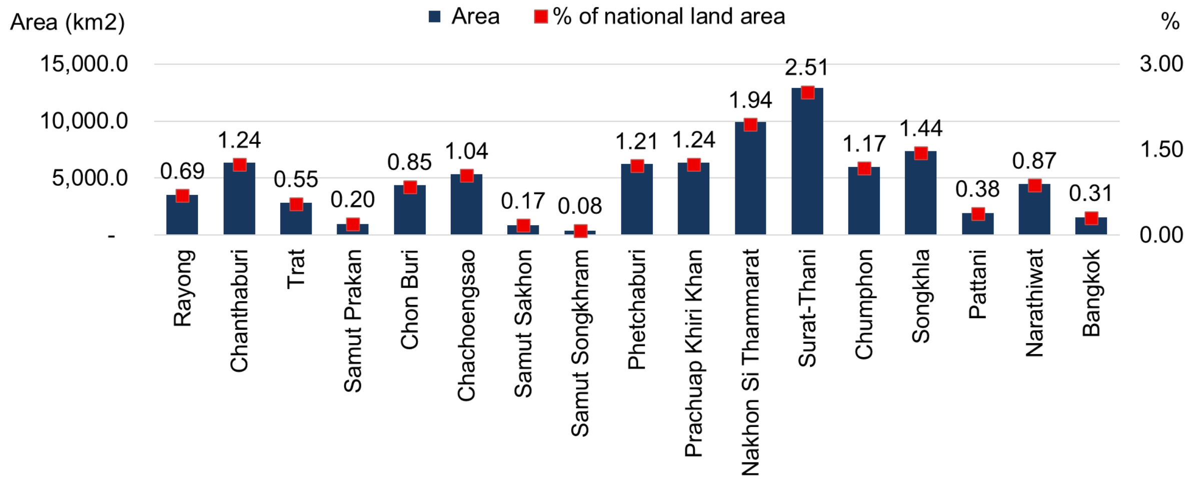
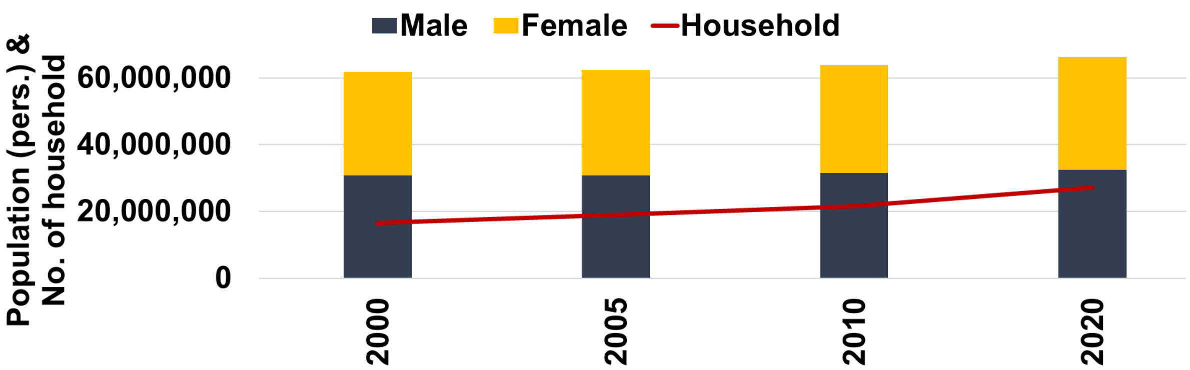


Figure 2.2 Land area and national share of coastal provinces along the Gulf of Thailand (2020)

Source: Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Between 2000 and 2020, Thailand's total population increased from 61.9 million to 66.2 million, reflecting a gradual national growth, with the 17 coastal provinces along the Gulf of Thailand accounting for approximately 18.6 million people in 2020. This population consists of nearly equal proportions of males and females, although the share of females increased to 51.7% **(Figure 2.3)** alongside a steady rise in the number of households due to smaller household sizes and urban migration. Provinces with the largest coastal populations include Nakhon Si Thammarat, Chon Buri, Songkhla, Samut Prakan, and notably Bangkok, which stands out as the most populous province with over 5.5 million residents and a predominance of females. In contrast, smaller provinces such as Samut Songkhram and Trat maintained populations below 300,000 **(Figure 2.4)**.



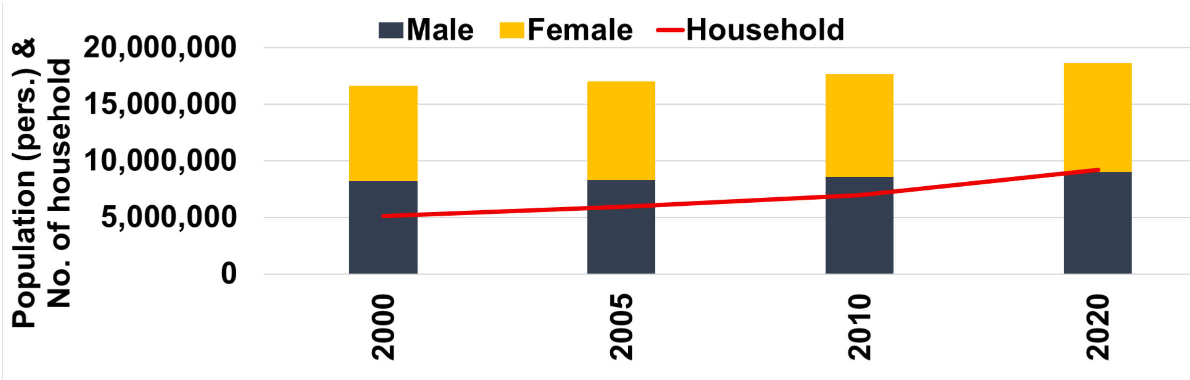


Figure 2.3 Population and Household Trends in Thailand (above) and Coastal Provinces along the Gulf of Thailand (below): 2000, 2005, 2010, 2020

Source: Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

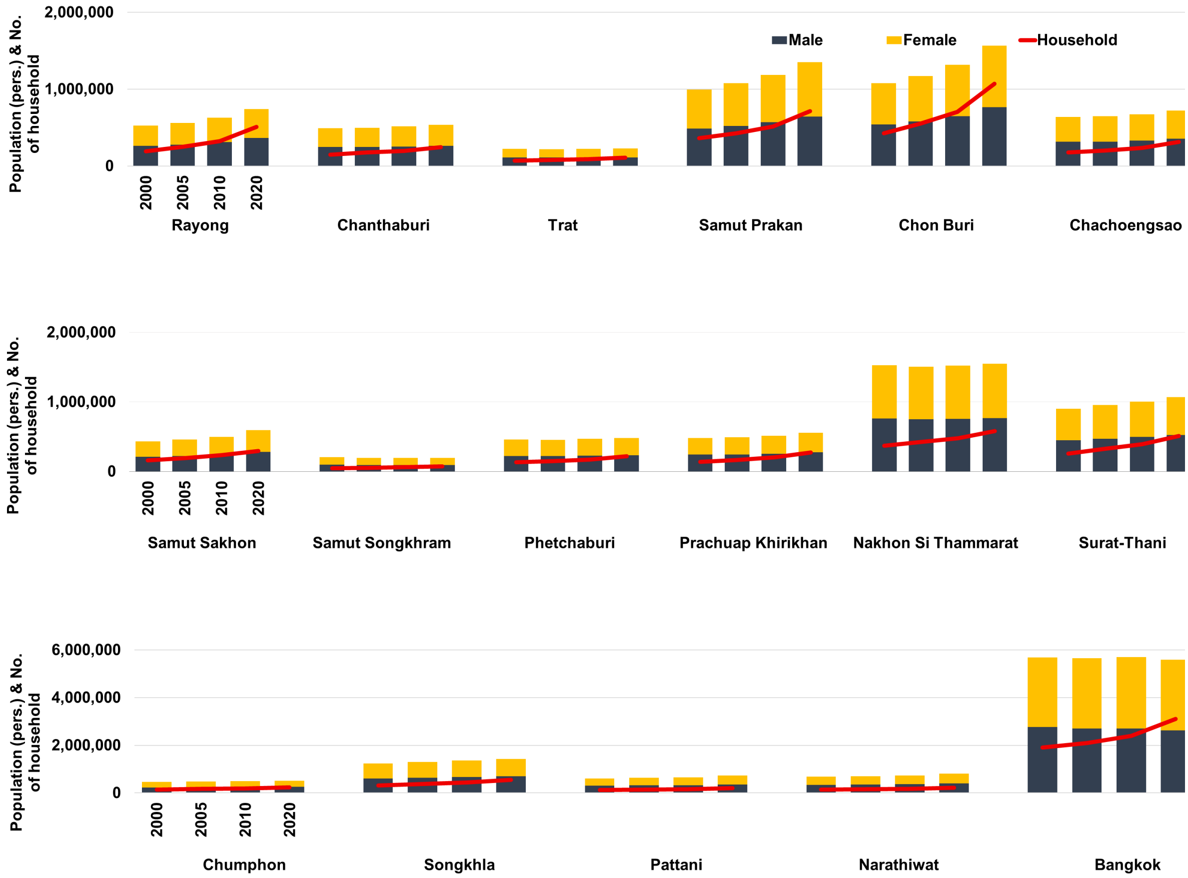


Figure 2.4 Population and household trends in Thailand's coastal provinces along the Gulf of Thailand (2000, 2005, 2010, 2020)

Source: Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Between 2000 and 2020, the population of Thailand's coastal provinces along the Gulf of Thailand grew at an average annual rate of 0.6–0.9% when excluding Bangkok, compared to 0.4–0.7% when Bangkok is included **(Table 2.1)**, which is considered a moderate level of growth by global demographic standards.

Table 2.1 Population growth rate (%) and household growth rate (%) of coastal provinces along the Gulf of Thailand (2000-2020)

Year	Population growth rate (%)		Household growth rate (%)	
	Without Bangkok	With Bangkok	Without Bangkok	With Bangkok
2000-2005	0.6	0.4	3.4	2.7
2005-2010	0.9	0.7	3.2	2.9
2010-2020	0.8	0.5	3.1	2.9

When considering the rate of change between 2000 and 2020, the annual household growth in coastal provinces excluding Bangkok declined from 3.4% to 3.1%, yet remains high. In contrast, the trend for coastal provinces including Bangkok diverges, with household growth stabilizing around 2.7–2.9% despite modest population growth of 0.4–0.7%. As noted by UN-Habitat (2016), households are growing faster than population due to declining household size, a pattern evident in Bangkok's shift toward smaller, fragmented urban living arrangements. This increase in households translates into higher demand for housing, energy, and coastal land resources (Liu et al., 2003; FAO, 2018), intensifying pressure on ecosystems in the land-constrained upper Gulf of Thailand.

Population and household growth trends vary significantly across the region. Economic hubs such as Chonburi (1.28–2.05%) and Rayong (1.13–2.01%) demonstrated relatively high population growth rates, while household growth was even more pronounced at 4.7% to over 5% annually (Figure 2.5), driven by tourism and industrial expansion. Conversely, provinces such as Samut Songkhram and Nakhon Si Thammarat recorded minimal or negative growth, likely reflecting outmigration and limited economic opportunities. Bangkok also experienced periods of slight population decline ranging from –0.06% to –0.32%, influenced by changing socio-economic conditions that have led to shifts in childbearing behavior, with people opting to have fewer or no children due to financial and time constraints **(Figure 2.5)**.

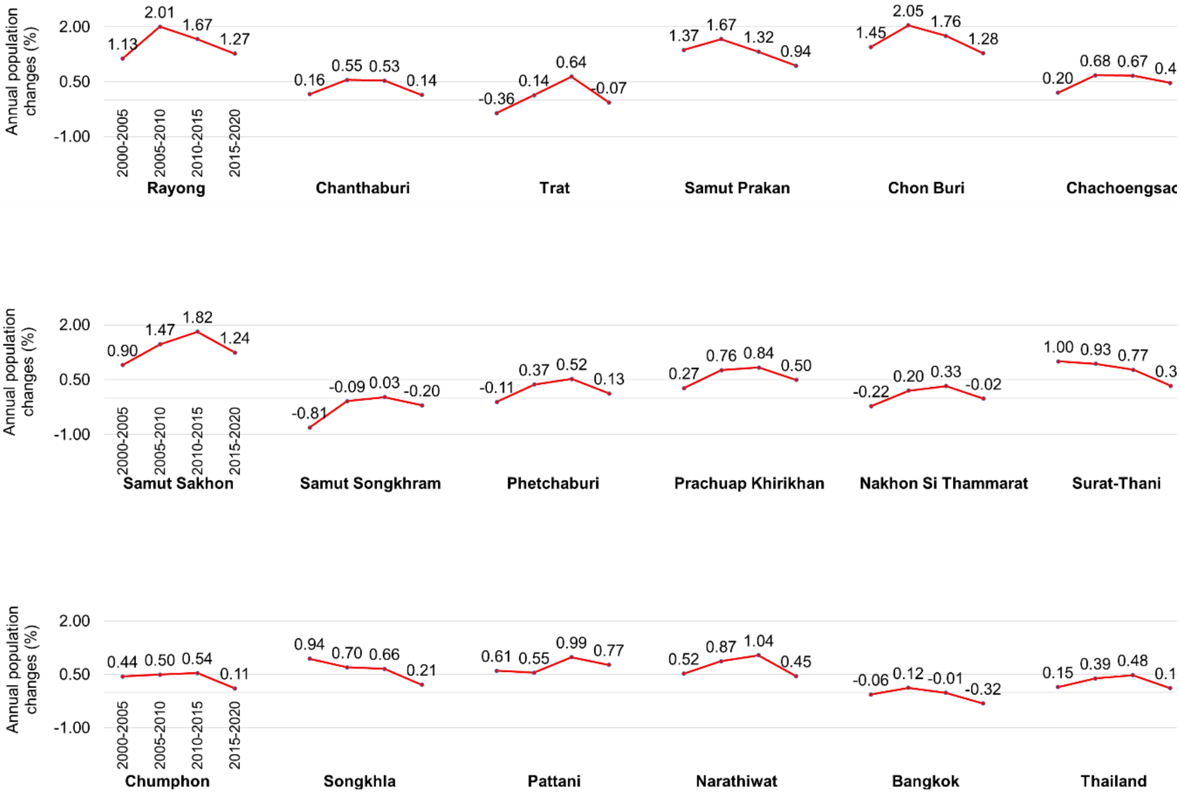


Figure 2.5 Annual population changes by coastal provinces along the Gulf of Thailand (2000-2020)

Source: Author's calculation based on data from Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Figure 2.6 presents the proportion of each coastal province's population relative to the national total for 2000, 2005, 2010, and 2020. While the overall coastal share has remained relatively stable, ranging from 26.8% to 28.1%, Bangkok alone accounted for the largest share, representing 9.2%, 9.1%, 8.9%, and 8.4% across these respective years. Although this share has gradually declined, Bangkok remains the central economic and administrative hub. Other provinces such as Samut Prakan and Chonburi also hold substantial shares due to their proximity to major urban centers and importance in industrial development, with Chonburi's increasing share aligning with the Eastern Economic Corridor (EEC) initiative. In contrast, provinces such as Trat and Samut Songkhram have consistently accounted for less than 1% of the national population each.

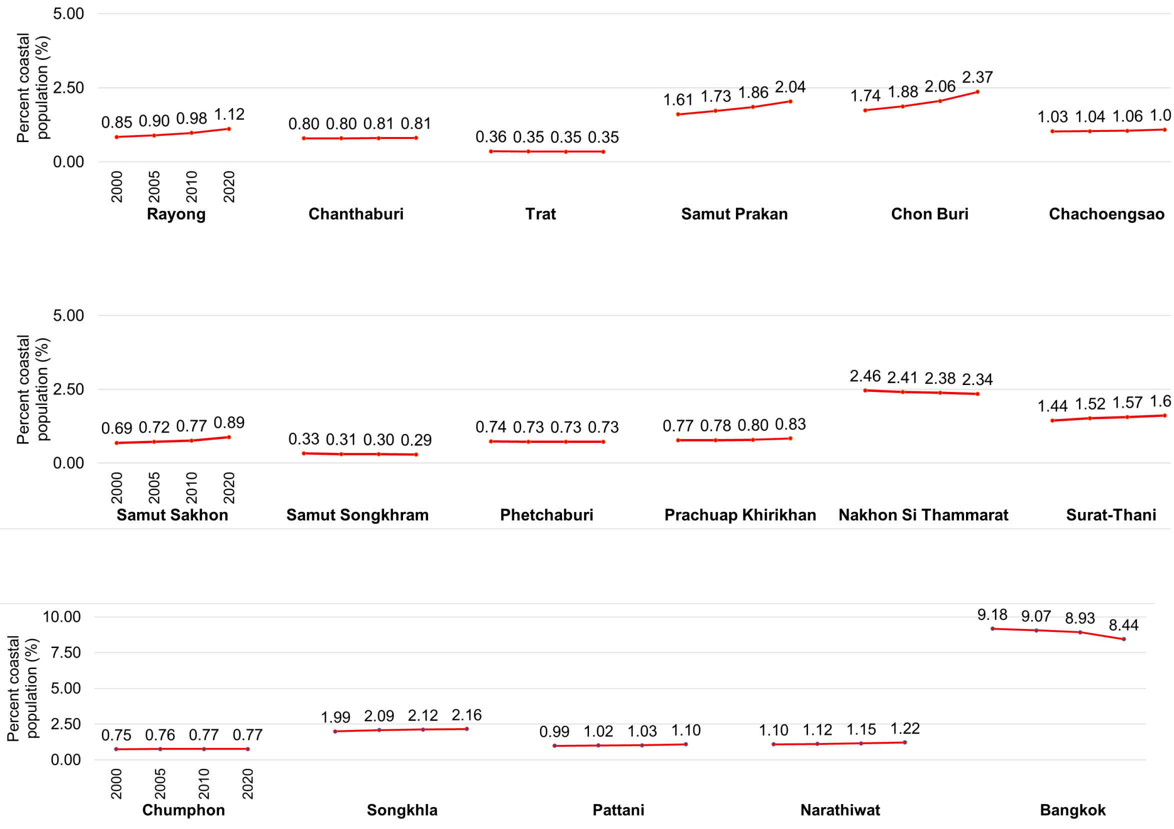


Figure 2.6 Provincial share of coastal population along the Gulf of Thailand (2000, 2005, 2010, 2020)

Source: Author's calculation based on data from Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Figure 2.7 illustrates the relationship between land area and population concentration from 2000 to 2020. While Thailand's national average density increased gradually from 121 to 129 persons/km², coastal provinces exhibit densities far exceeding this benchmark. Bangkok consistently recorded the highest extreme concentration, ranging between 3,562 and 3,634 persons/km². Similarly, Samut Prakan (992–1,346 persons/km²), Samut Sakhon (492–672 persons/km²), and Samut Songkhram (461–492 persons/km²) display densities significantly higher than the national level due to large populations confined within limited land areas.

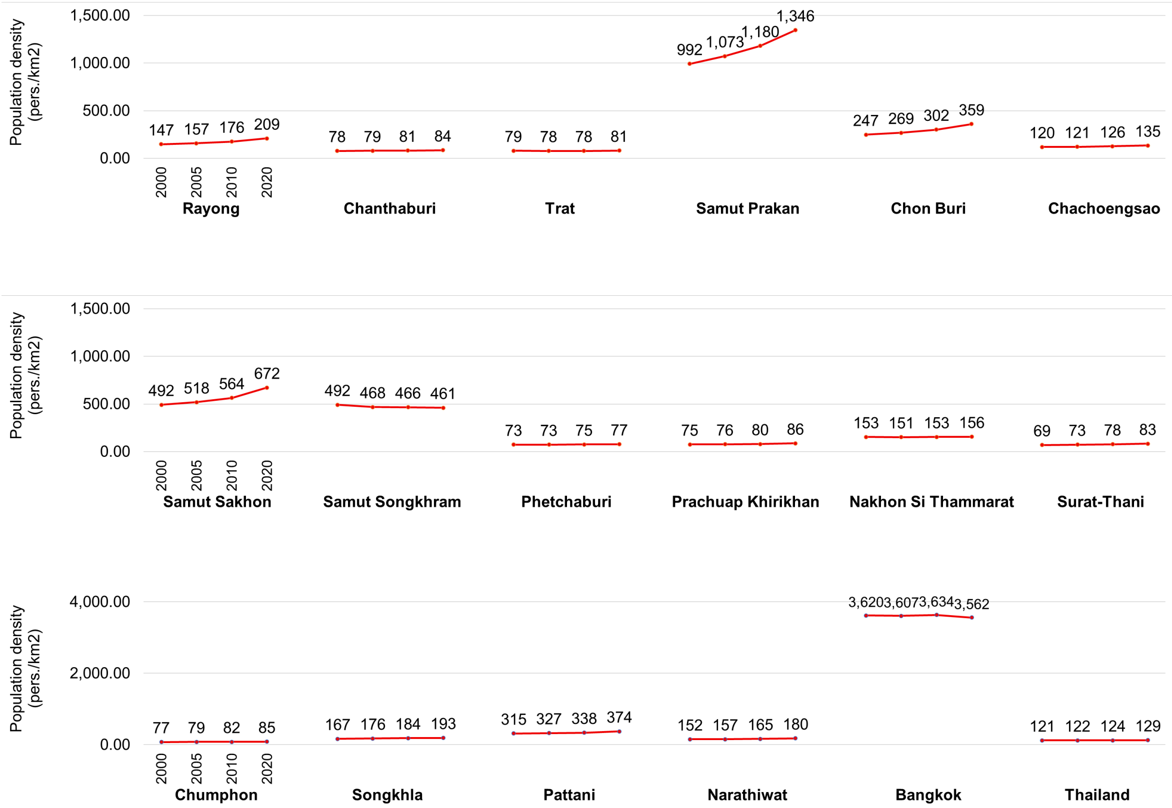


Figure 2.7 Population density of Thailand and coastal provinces along the Gulf of Thailand (2000, 2005, 2010, 2020)

Source: Author's calculation based on data from Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

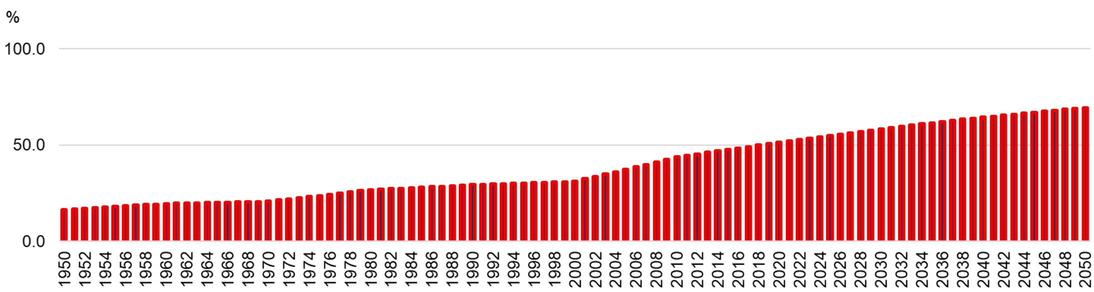


Figure 2.8 Percentage of population at mid-year residing in urban areas of Thailand (1950-2050)

Source: United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision, Online Edition.

As illustrated in **Figure 2.8**, the percentage of Thailand's population residing in urban areas rose from 16.5% in 1950 to 51.4% by 2020, with projections reaching approximately 69.5% by 2050. This trend reflects economic growth, rural-to-urban migration, and infrastructure expansion.

The 2020 urban population ratio and density data reveal distinct spatial patterns among coastal provinces **(Table 2.2)**. While the national average indicates moderate urbanization (34.5% share, 129 persons/km^2), coastal areas exhibit stronger contrasts. The upper Gulf forms Thailand’s primary urban corridor, extending from Bangkok to the Eastern Economic Corridor (EEC), where industrial development dominates. Key provinces here include Bangkok (100%, 3,562 persons/km^2), Samut Prakan (48.6%, 1,346), Samut Sakhon (45.6%, 672), and Chon Buri (68.9%, 359). In contrast, lower Gulf provinces such as Chumphon, Narathiwat, and Nakhon Si Thammarat reflect predominantly rural settlement patterns with low urban ratios (< 25%) and densities (< 200 persons/km^2).

Table 2.2 Urban population ratio and population density of Thailand and coastal provinces along the Gulf of Thailand (2020)

Provinces	Urban population ratio (%)	Density (pers./km^2)
Nation	34.5	129
Rayong	48.6	209
Chanthaburi	42.3	84
Trat	24.4	81
Samut Prakan	48.6	1,346
Chon Buri	68.9	359
Chachoengsao	21.8	135
Samut Sakhon	45.6	672
Samut Songkhram	19.8	461
Phetchaburi	33.9	77
Prachuap Khiri Khan	31.2	86
Nakhon Si Thammarat	18.8	156
Surat-Thani	41.3	83
Chumphon	19.1	85
Songkhla	50.8	193

Pattani	17.9	374
Narathiwat	20.8	180
Bangkok	100.0	3,562

Figure 2.9 illustrates the progressive loss of Thailand's natural and semi-natural vegetated land between 2005 and 2022. The indicator reports the loss as a percentage of the natural and semi-natural land area in the base year 2000, increasing from **1.26% in 2005** to **2.13% in 2022**. This pattern suggests a continued conversion of vegetated land to other land uses over the period.

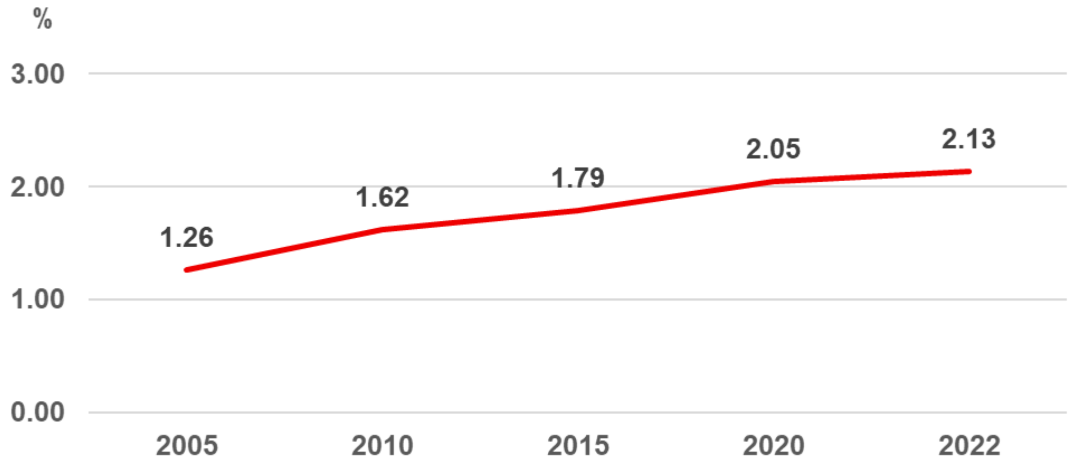


Figure 2.9 Loss of natural and semi-natural vegetated land in Thailand (2005, 2010, 2015, 2020, 2022)

Source: OECD Data Explorer. 2025. Land cover and land change. https://data-explorer.oecd.org/ (accessed 25 May 2025)

2.2.2 Human wellbeing

Poverty in coastal areas is a key indicator of vulnerability, particularly where communities depend on open-access ecosystems such as coastal fisheries, mangroves, and intertidal zones. While population size alone does not adequately reflect pressure, the number of poor residents provides a direct measure of subsistence dependence. National statistics from 2000 to 2020 reveal a significant reduction in those living below the poverty line, falling from approximately 25.7 million (41.7%) to 4.7 million (7.2%), representing an average annual reduction of 4.1%

(**Figure 2.10**). This positive trend reflects broader socioeconomic developments, including agricultural expansion and targeted government assistance via social protection schemes and improved access to public services. Together, these factors have contributed to a marked reduction in poverty and a consequent shift in natural resource dependence patterns in coastal regions.

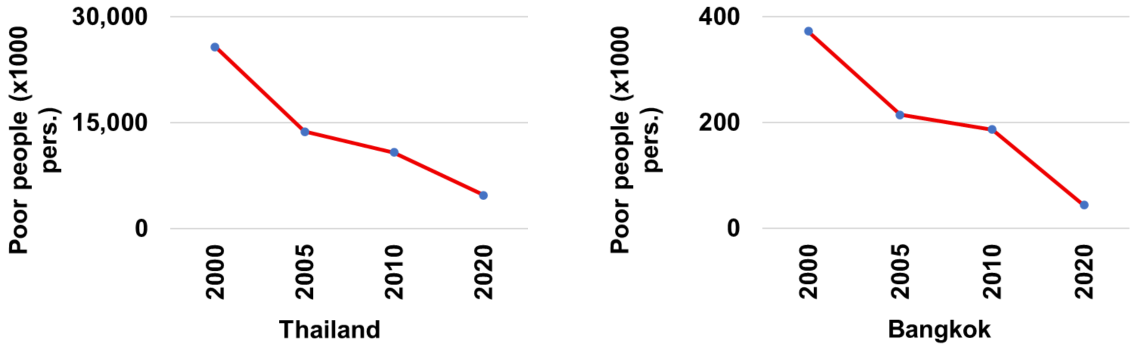


Figure 2.10 Poor people of Thailand and Bangkok province (2000, 2006, 2010, 2020)

Source: Office of the National Economic and Social Development Council. 2025. Household Socio-Economic Survey by the National Statistical Office; compiled by the Division of Social Data and Indicators Development, NESDC. https://www.nesdc.go.th/main.php?filename=social (accessed 22 April 2025)

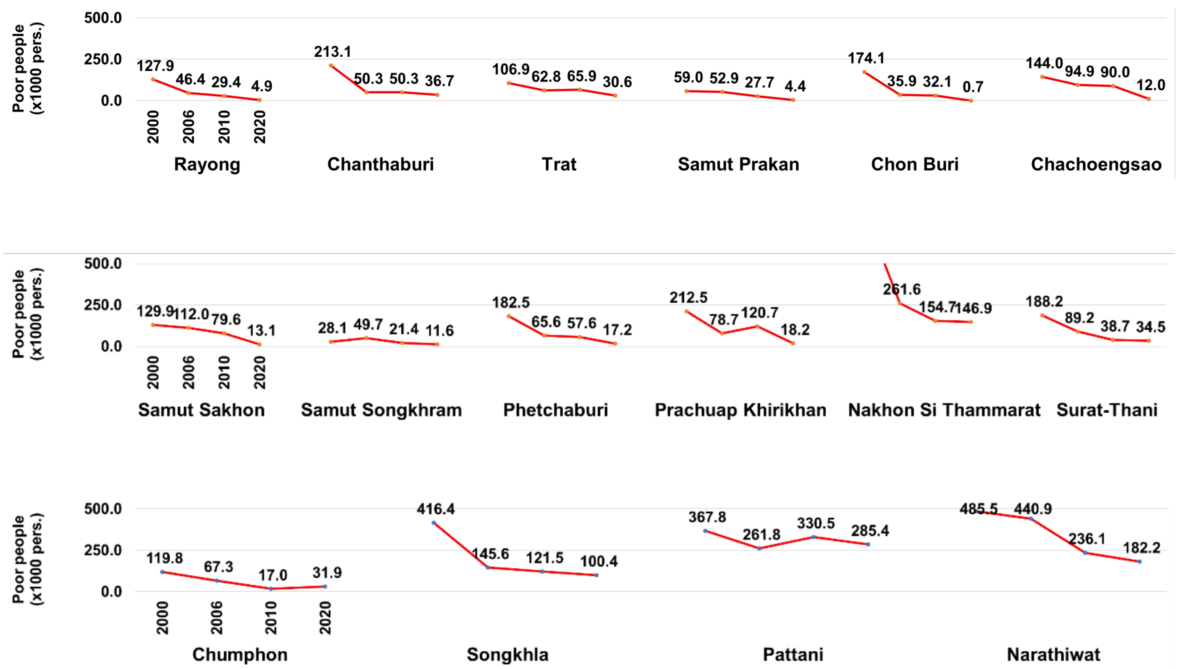


Figure 2.11 Poor people in coastal provinces along the Gulf of Thailand (2000, 2006, 2010, 2020)

Source: Office of the National Economic and Social Development Council. 2025. Household Socio-Economic Survey by the National Statistical Office; compiled by the Division of Social Data and Indicators Development, NESDC. https://www.nesdc.go.th/main.php?filename=social (accessed 22 April 2025)

Data from the 17 coastal provinces shows significant but unequal progress in reducing poverty **(Figure 2.11)**. Industrial hubs like Rayong, Chonburi, and Samut Prakan achieved dramatic declines driven by the Eastern Economic Corridor (EEC), with Rayong's poor population dropping over 96% to just 4,900. Bangkok also saw significant improvement, falling to 44,100. Conversely, southern provinces face persistent poverty where Pattani saw only slight improvement to 285,400 and Narathiwat recorded over 182,000, reflecting complex local issues. These regional differences are critical as high poverty often correlates with reliance on fragile ecosystems.

Regarding SDG 1, Thailand is broadly on track to end extreme poverty by 2030 provided social protection continues. However, progress varies significantly. While industrial coastal provinces may meet targets early, persistent poverty in Pattani and Narathiwat requires area-specific, conflict-sensitive, and livelihood-diversification measures. Without such interventions, Thailand risks meeting SDG 1 nationally while retaining significant coastal pockets of poverty.

Contemporary Human Development Index (HDI)

Thailand's HDI has shown steady progress over the past three decades, rising from 0.584 in 1990 to 0.742 by 2010 due to improvements in life expectancy, education attainment, and gross national income per capita **(Figure 2.12)**. The index reached 0.800 in 2021 before experiencing a slight dip to 0.792 in 2022 and subsequently recovering to 0.798 in 2023.

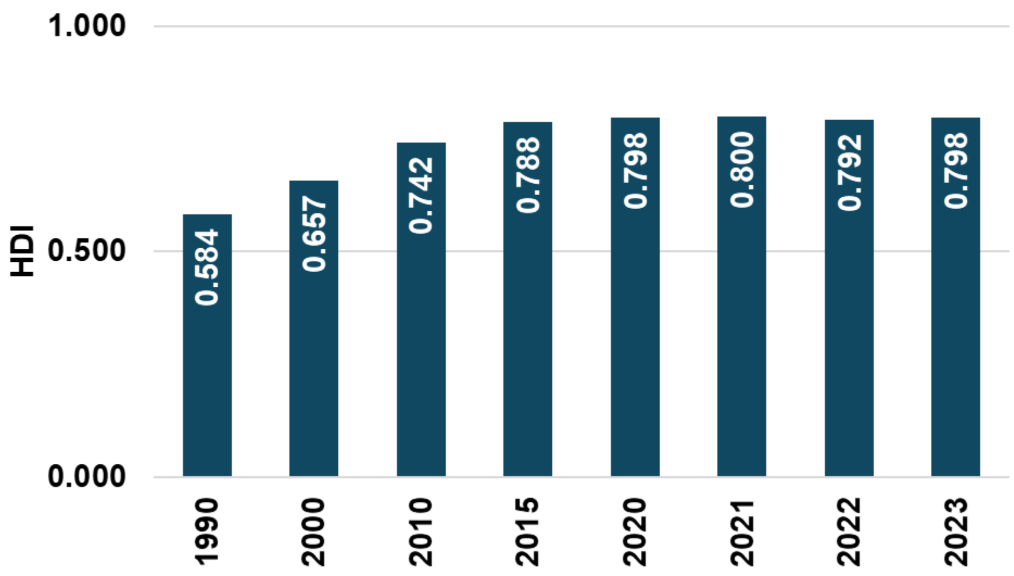


Figure 2.12 HDI of Thailand (1990-2023)

Source: UNDP. 2025. Human Development Reports. https://hdr.undp.org/data-center/documentation-and-downloads (accessed 22 April 2025)

Inequality-adjusted human development index (IHDI)

From 2012 to 2023, Thailand's IHDI increased from 0.622 to 0.677, signaling reduced overall inequality across key development sectors likely stemming from better healthcare, education, and targeted social policies **(Figure 2.13)**. While the index temporarily dropped to 0.670 between 2020 and 2022 due to COVID-19 disruptions, it rebounded to 0.677 in 2023, indicating the country is recovering from these recent vulnerabilities.

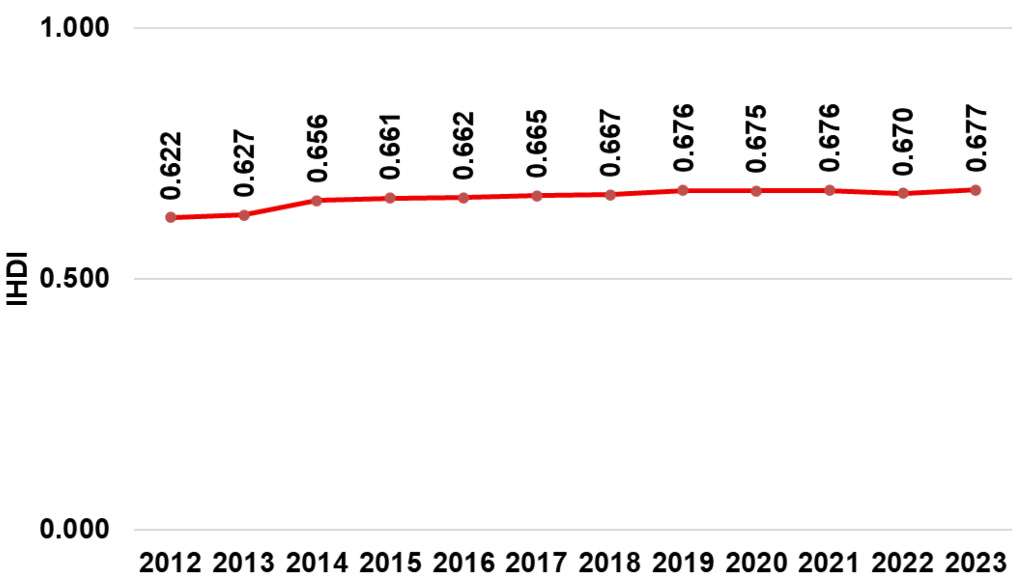
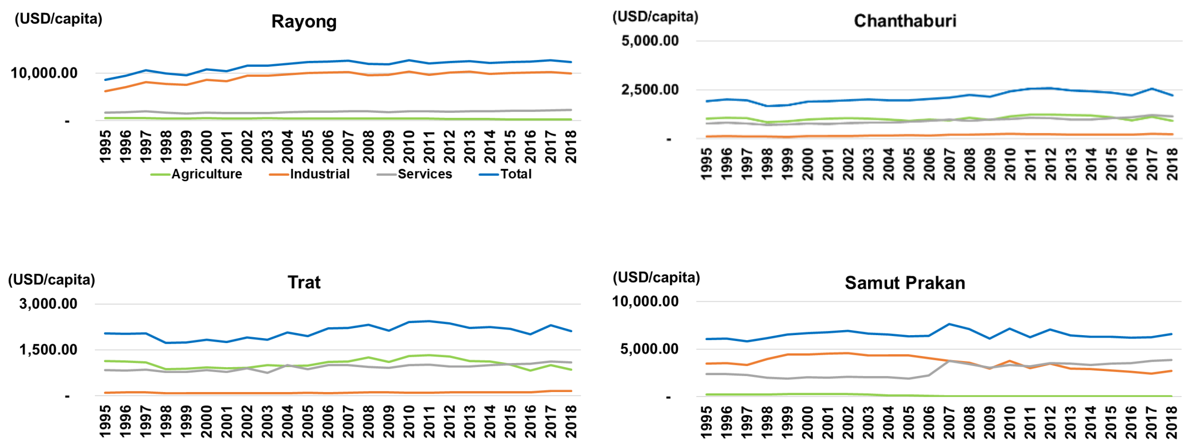


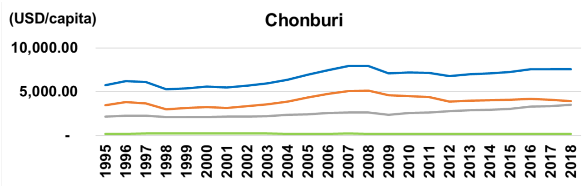
Figure 2.13 IHDI of Thailand (2012-2023)

Source: UNDP. 2025. Human Development Reports. https://hdr.undp.org/data-center/documentation-and-downloads (accessed 22 April 2025)

2.2.3 Economic activities

Provincial GDP data highlights varying degrees of economic diversification as shown in **Figure 2.14**. The service sector dominates tourism destinations like Phetchaburi and Songkhla while agriculture plays a major role in Trat. Conversely, industrial activity is clustered in Chon Buri, Rayong, Chachoengsao, and Samut Sakhon due to proximity to ports and special economic zones.

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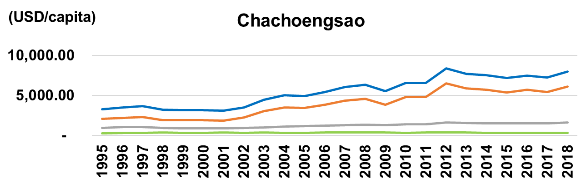
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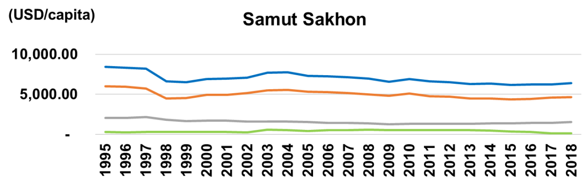
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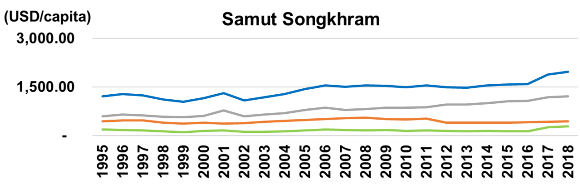
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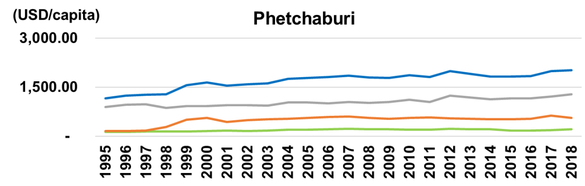
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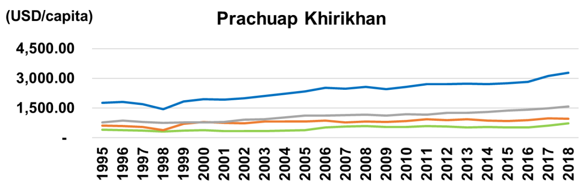
(USD/capita)
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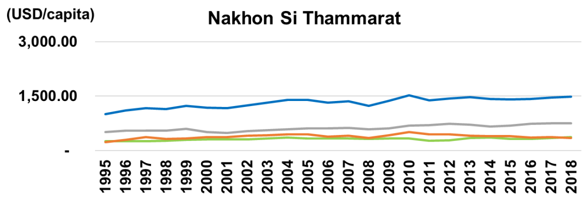
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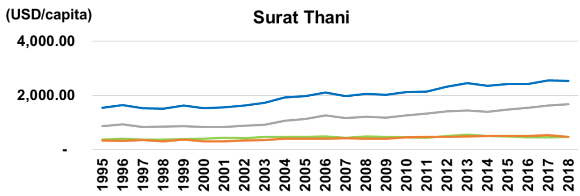
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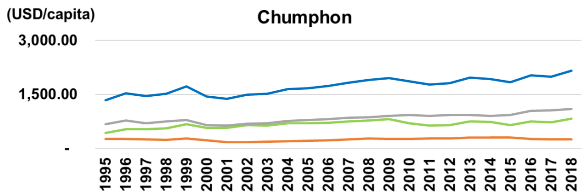
(USD/capita)
Chumphon
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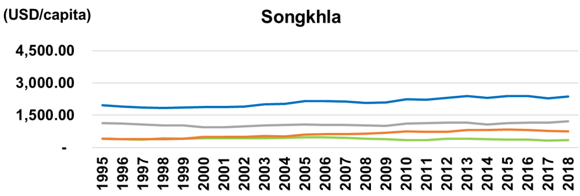
(USD/capita)
Songkhla
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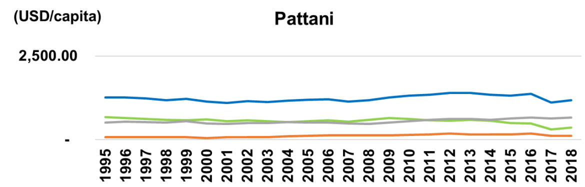
(USD/capita)
Pattani
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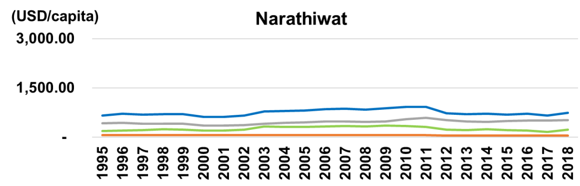
(USD/capita)
Narathiwat
3,000.00
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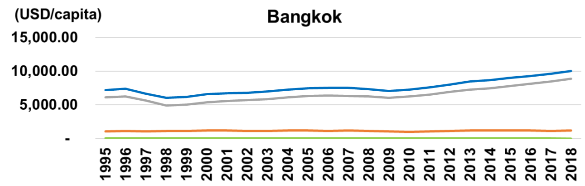
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018


(USD/capita)
Bangkok
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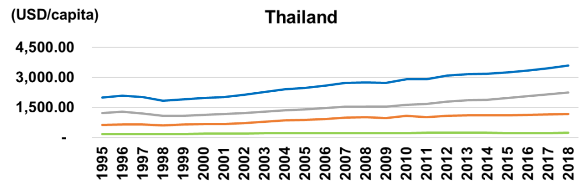
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018


(USD/capita)
Thailand
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1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

Figure 2.14 GDP per capita by sector (agriculture, industrial, services) of coastal provinces along the Gulf of Thailand (1995-2018)

Source: Office of the National Economic and Social Development Council. 2025. GDP. https://www.nesdc.go.th/nesdb_en/more_news.php?cid=156&filename=index (Accessed 21 Apr 2025)

A broader comparison highlights clear differences between the national economy and Bangkok. The capital is heavily reliant on the service sector, consistent with its role as the primary commercial hub. Nationally, the economic structure is more balanced, featuring strong contributions from both services and industry, the latter supported by export-oriented investments. In both contexts, agriculture is no longer the dominant sector, though it remains a supporting pillar of the economy.

Sustainable fisheries contribution to GDP

Between 2011 and 2021, the contribution of sustainable fisheries to Thailand's GDP dropped from 0.45% to 0.28% **(Figure 2.15)**. This downward trend coincided with a period of broader structural shifts in the economy and the strict enforcement of measures against Illegal, Unreported, and Unregulated (IUU) fishing. In this changing environment, the sector faces the critical task of balancing ecological compliance with the economic stability of fishing communities.

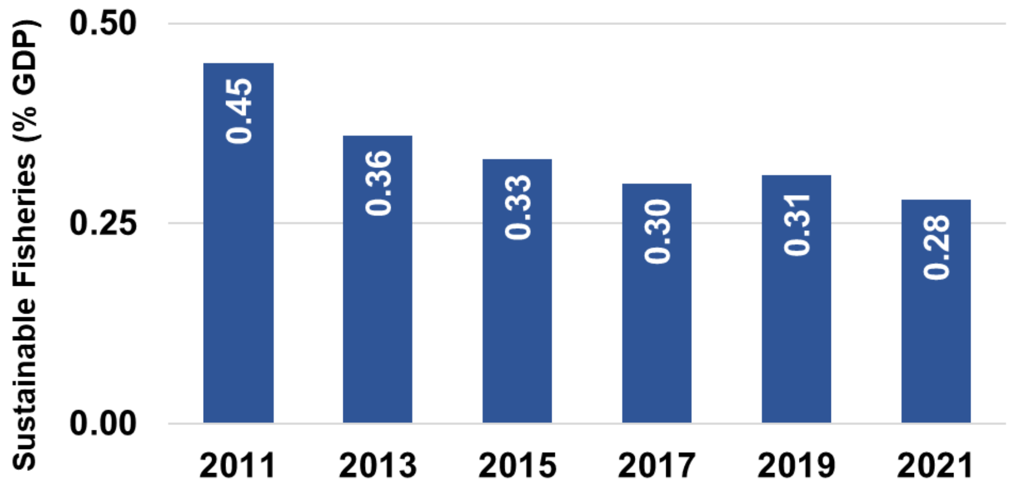

Figure 2.15 Sustainable fisheries as a percentage of GDP in Thailand (2011-2021)

Source: FAO. 2025. Sustainable fisheries as a proportion of GDP. https://de-public-statsuite.fao.org/

(Accessed 25 June 2025)

Tourism percent of GDP

Thailand's tourism sector saw robust growth between 2010 and 2019, with its GDP contribution climbing from 3.56% to a peak of over 7.4% **(Figure 2.16)**. This expansion established tourism as a critical economic driver, particularly for coastal destinations like Phuket and Chon Buri, while also increasing the demand for infrastructure and resources. The trend, however, was drastically reversed by the COVID-19 pandemic, which caused the sector's share to drop to 0.84% by 2021 due to global travel disruptions.

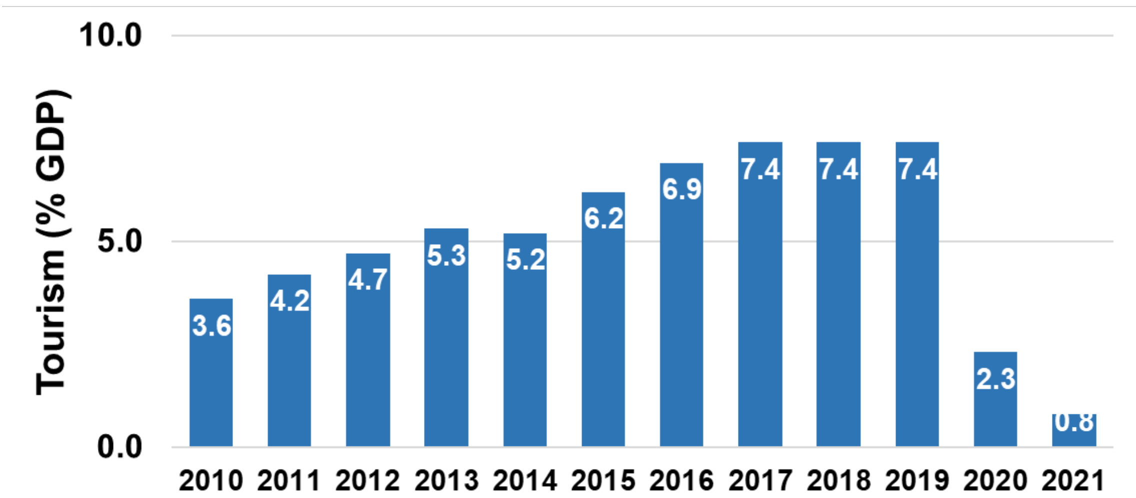

Figure 2.16 Tourism as a percentage of GDP in Thailand (2011-2021)

Source: Our World in Data. 2024. Tourism's contribution to GDP. https://www.unwto.org/tourism-statistics/economic-contribution-SDG (Accessed 25 June 2025)

2.2.4 Climate-related threats

Tropical cyclones remain a major threat to Thailand's coastal economies and natural resources. Data from the Thai Meteorological Department (2000–2024) indicates an annual average of 1.6 cyclones, peaking at three in specific years **(Figure 2.17)**. Although long-term frequency shows no clear increase, significant annual variation highlights climate uncertainty, demanding strong disaster response mechanisms to protect high-risk areas from storm surges.

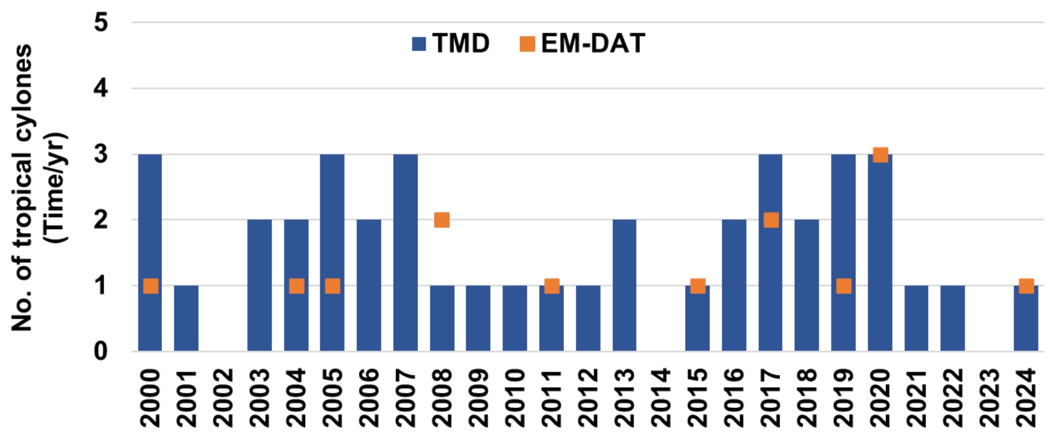

Figure 2.17 Number of tropical cyclones per year of Thailand (2000-2024) from Thai Meteorological Department (TMD) and EM-DAT

Source: EM-DAT, CRED / UCLouvain. 2025. www.emdat.be (Accessed 25 Jun 2025); TMD. 2025. Tropical Cyclones in Thailand (1951-2024).

Although storm frequency has not steadily increased, human impact varies significantly. Data between 2000 and 2024 highlights this unpredictability, with death tolls surging to 45 in 2024 and exceeding 10 in 2005 and 2020, in sharp contrast to years like 2008 and 2017 with zero recorded deaths **(Figure 2.18)**. These contrasts expose the fragility of low-lying coastal areas, reinforcing the urgent need for effective early warning systems and community-based risk reduction to minimize fatalities.

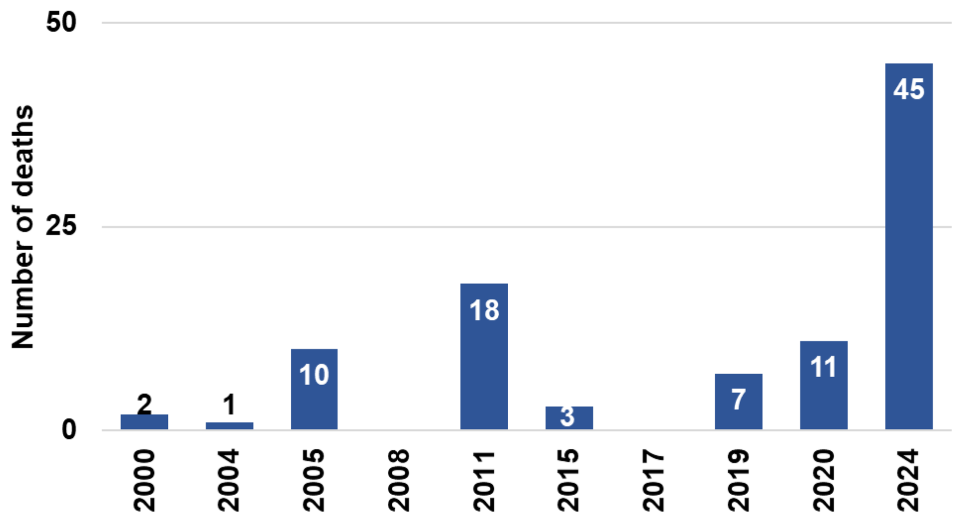

Figure 2.18 Number of deaths from tropical cyclones per year of Thailand (2000-2024)

Source: EM-DAT, CRED / UCLouvain. 2025. www.emdat.be (Accessed 25 Jun 2025)

Data on cyclone-related damages in Thailand (2005–2024) reveal significant annual variation. Losses ranged from USD 20 million in 2005 (USD 32.1 million adjusted) and a minor USD 561,000 in 2015 (USD 742,000 adjusted) to a peak of USD 904 million in 2024 **(Figure 2.19)**.

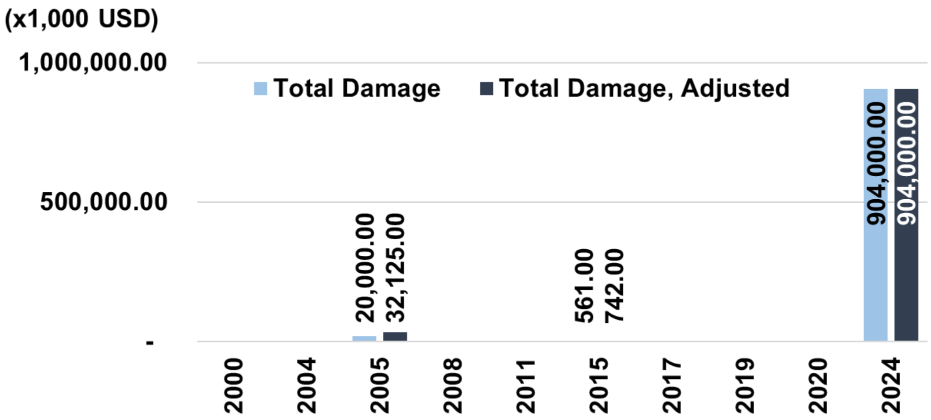

Figure 2.19 Total damage and total damage (adjusted) due to tropical cyclones of Thailand (2000-2024)

Source: EM-DAT, CRED / UCLouvain. 2025. www.emdat.be (Accessed 25 Jun 2025)

2.3 Discussion and conclusions

2.3.1 Risk assessment from socioeconomic trends

For sustainable management, a Composite Risk Index (CRI) was established to quantify risk across 17 Gulf of Thailand provinces based on the DPSIR framework (EEA, 1999; Kristensen, 2004). Calculated as CRI = 0.5×PI + 0.5×VI, the index equally weights Pressure (PI) and Vulnerability (VI). The PI aggregates three socioeconomic drivers: population dynamics (2000–2020), current population density (2020), and economic pressure derived from gross provincial product (2000-2020). The VI averages social sensitivity proxies: changes in poverty headcount and gender ratio imbalance (2000–2020). All indicators are normalized to a [0,1] scale. Notably, critical physical exposure variables such as elevation metrics and tropical cyclone statistics were excluded due to a lack of provincial resolution, ensuring the index remains spatially consistent and comparable across all provinces.

The 'Risk intensity' format (CRI_Unweighted) measures severity independent of physical size, identifying Bangkok (0.646), Samut Songkhram (0.538), and Samut Prakan (0.419) as highest-risk **(Table 2.3)**. Drivers vary from concentrated economic and industrial activity in Bangkok and Samut Prakan to high population density within Samut Songkhram's confined territory. Conversely, Rayong registered the lowest intensity at 0.261.

Table 2.3 Risk intensity assessment (CRI_Unweighted) and provincial ranking

Province	Pressure index (PI) score	Vulnerability index (VI) score	Risk intensity score (CRI_Unweighted)	Intensity rank
Bangkok	0.586	0.706	0.646	1
Samut Songkhram	0.337	0.740	0.538	2
Samut Prakan	0.332	0.506	0.419	3
Samut Sakhon	0.316	0.438	0.377	4
Chumphon	0.382	0.362	0.372	5
Pattani	0.209	0.531	0.370	6
Songkhla	0.264	0.470	0.367	7
Chachoengsao	0.458	0.253	0.355	8
Surat-Thani	0.369	0.326	0.348	9
Phetchaburi	0.219	0.452	0.336	10
Chon Buri	0.497	0.160	0.329	11
Chanthaburi	0.249	0.378	0.314	12
Narathiwat	0.226	0.401	0.314	13
Prachuap Khiri Khan	0.387	0.148	0.268	14
Trat	0.183	0.346	0.265	15
Nakhon Si Thammarat	0.231	0.293	0.262	16
Rayong	0.425	0.098	0.261	17

Incorporating area weighting, the 'Overall risk magnitude' (CRI_Final) measures total risk volume rather than concentration, causing a distinct shift in priorities. Surat Thani (0.055), Songkhla (0.033), and Nakhon Si Thammarat (0.032) rise to the top **(Table 2.4)** as extensive geography increases the aggregate exposure of critical habitats and communities. Conversely, rankings for smaller provinces like Samut Songkhram and Samut Sakhon decline, confirming that while local pressures are intense, overall resource exposure is limited by size.

Table 2.4 Overall risk magnitude assessment (CRI_Final) and provincial ranking after area weighting

Province	Risk intensity score (CRI_Unweighted)	Intensity rank	Area weight	Risk magnitude score (CRI_Final)	Final rank
Surat-Thani	0.348	9	0.158	0.055	1
Songkhla	0.367	7	0.091	0.033	2
Nakhon Si Thammarat	0.262	16	0.122	0.032	3
Chumphon	0.372	5	0.074	0.027	4
Phetchaburi	0.336	10	0.076	0.026	5
Chanthaburi	0.314	12	0.078	0.024	6
Chachoengsao	0.355	8	0.066	0.023	7
Prachuap Khiri Khan	0.268	14	0.078	0.021	8
Chon Buri	0.329	11	0.054	0.018	9
Narathiwat	0.314	13	0.055	0.017	10
Bangkok	0.646	1	0.019	0.012	11
Rayong	0.261	17	0.044	0.011	12
Trat	0.265	15	0.035	0.009	13
Pattani	0.370	6	0.024	0.009	14
Samut Prakan	0.419	3	0.012	0.005	15
Samut Sakhon	0.377	4	0.011	0.004	16
Samut Songkhram	0.538	2	0.005	0.003	17
Total			1.000		

Finally, the 'Hybrid-risk group,' exemplified by Chumphon (Intensity rank 5, Magnitude rank 4), faces the dual burden of intense pressure and large scale. This 'double-risk' status creates a complex management scenario requiring a complete response that combines urgent action for specific areas with long-term planning for vast resources.

This risk assessment identifies three priority groups essential for policy planning. The 'Pure intensity risk' group (e.g., Bangkok, Samut Songkhram) requires urgent spatial management to control concentrated pressures in small areas. The 'Pure magnitude risk' group (e.g., Surat Thani, Songkhla) demands large-scale resource management and budgetary allocation due to extensive resource portfolios despite lower intensity. Finally, the 'Hybrid-risk group' (e.g., Chumphon) ranks high in both dimensions requiring complex integrated responses that combine urgent management with large-scale planning. This analysis serves as a critical tool for prioritizing interventions and designing effective responses.

2.3.2 Risk assessment from climate- and environment-related threats

The socioeconomic risks identified in section 2.3.1 are compounded by physical, climate- and environment-related threats. Although province-level physical vulnerability data is unavailable, the broader hazard context is critical as the Gulf of Thailand persistently faces hydrometeorological hazards including coastal erosion, storm surges, and tropical cyclones.

National-level data **(Figures 2.17–2.19)** confirms this persistent threat, showing numerous cyclone events annually between 2000 and 2024. These events have caused significant economic damages and loss of life, with recorded losses of approximately $32 million in 2005, $742,000 in 2015, and a severe $904 million in 2024. While this data covers the national level, the 17 coastal provinces are primary targets. Consequently, this general exposure acts as a risk multiplier, threatening to amplify the socioeconomic weaknesses, such as poverty and dense settlements, identified in the CRI assessment.

2.3.3 Mitigating socioeconomic vulnerability from climate-mediated environmental change- current actions and gaps

Thailand implements a structured policy system to build coastal resilience against climate change risks across three levels. Level 1 sets the long-term vision through the National Strategy. Level 2 guides mid-term planning via the Master Plan under the National Strategy (2023 to 2037) and the 13th National Economic and Social Development Plan (NESDP) for 2023 to 2027. Level 3 executes these strategies through specific agency plans, including the Department of Climate Change and Environment’s 5 Year Action Plan.

The 20 Year National Strategy (2018 to 2037) addresses unpredictable climate change threats to lives, infrastructure, food security, and ecosystems. It targets a stable nation with sustainable natural resources by fostering environmentally friendly growth. This vision builds a climate friendly society that reduces greenhouse gas emissions and adapts to minimize disaster loss. These goals serve as the foundation for the National Economic and Social Development Plan and other master plans.

Level 2 translates the National Strategy into the Master Plan under the National Strategy (2023 to 2037), specifically Issue 18 on sustainable growth. This issue features a sub-plan for creating a climate friendly society aimed at lowering greenhouse gas emissions. The plan outlines four development guidelines: reducing emissions, adapting to minimize loss from natural disasters, promoting climate friendly infrastructure investments, and enhancing adaptation and emission reduction capacity.

The 13th National Economic and Social Development Plan (NESDP) for 2023 to 2027 puts this vision into practice toward Security, Prosperity, and Sustainability based on the Sufficiency Economy Philosophy. It aims to transform the country into a progressive, value driven, and sustainable society. The plan prioritizes building resilience against global risks like climate change to reduce socioeconomic vulnerability. It establishes 13 specific Development milestones to direct national action.

Milestone 11 builds capacity to reduce disaster and climate change impacts through three primary objectives. First involves minimizing damage by lowering fatalities, economic loss, and affected areas. Second lowers exposure using provincial risk maps and effective early warning systems. Third strengthens societal resilience, targeting 80% community self-management by 2027 and expanded insurance access. These efforts utilize five strategies: preventing risks in critical zones, building community skills, utilizing technology, restoring ecosystems, and promoting international cooperation.

At practical Level 3 broad national strategies turn into action through agency specific plans like the Department of Climate Change and Environment (DCCE) 5 Year Action Plan (2023 to 2027). This plan guides the department under the Ministry of Natural Resources and Environment toward climate resilience and a low carbon lifestyle. To achieve this the DCCE focuses on five areas aligning policy with global commitments, creating tools for adaptation and mitigation, building public networks, improving data for governance, and strengthening the organization.

In essence, Thailand's implementation, as reflected in the previously mentioned plans, is presented in **Table 2.5**.

Table 2.5 Significance of the implementation driven by the DCCE

Issue	Key implementation aspects
Impacts of climate change at both the global and national levels (Thailand)	1. Assessing impacts and developing risk datasets from climate change, covering 6 adaptation sectors, such as: agriculture and food security, water management and disasters, tourism, public health, natural resource management, and the human settlement and security sector, including area-based risks. 2. Formulation of policies and plans for climate change adaptation. 3. Driving and promoting public readiness to adapt to climate change. 4. Developing adaptation plans at the policy and area levels to cover the adaptation sectors, including the implementation of efficient and effective adaptation measures. 5. Driving and implementing actions at the policy level in collaboration with central and local agencies to drive area-based adaptation and scale up implementation. 6. Monitoring and evaluation of implementation and ensuring continuous improvement.
GHG Mitigation, Carbon Neutrality, and Net-Zero	1. Assess the potential for greenhouse gas (GHG) mitigation and develop policies and plans, including setting national GHG-reduction targets that cover the five key sectors: energy; industrial processes and product use (IPPU); waste; agriculture; and land use and forestry. 2. Prepare and submit implementation reports on the plans and targets that Thailand has pledged, in accordance with the submission timelines under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, such as

	National Communications (NCs) and Biennial Transparency Reports (BTRs). 3. Drive and implement climate policy in coordination with central and local government agencies. 4. Promote and enable the public to be ready to develop and adopt low-GHG lifestyles. 5. Advance GHG mitigation actions across sectors and at subnational levels, and scale up successful initiatives. 6. Continuously monitor and evaluate progress and improve implementation.

Even with these solid policies in place, putting them into practice remains difficult. A review of the DCCE's analysis highlights serious obstacles that stand in the way of reducing risks for the population. These challenges generally fall into two main groups:

1. Strategic and technical gaps

These challenges arise from the complex nature of the climate problem itself and the tools available to address it:

- Scientific uncertainty remains a primary gap in conducting precise risk assessments. While general climate impacts are understood significant uncertainty persists regarding specific timing severity and exact location. This lack of precision limits targeted cost effective adaptation policies and complicates clear public communication.
- Problem complexity and integration make management difficult as climate change affects multiple sectors. A fragmented approach persists where economic development policies are not fully integrated with climate adaptation goals often leading to conflicting objectives. National frameworks like NESDP Milestone 11 set general goals but deploy a one size fits all approach. This fails to address distinct needs of priority groups specifically Intensity risk provinces like Bangkok, Magnitude risk group like Surat Thani or Hybrid risk group like Chumphon.

2. Operational and institutional gaps

These challenges concern the ability of key institutions, particularly the DCCE, to carry out the national strategy effectively:

- Expanded mandate vs resource constraints arise as the DCCE faces a heavier workload from severe climate impacts like frequent disasters and ecosystem loss. Although new specialized divisions for GHG reduction and adaptation were established this wider scope creates a resource shortage. Consequently, the agency requires significant new funding modern monitoring technology and continuous personnel training to meet demands.
- Cooperation and communication gaps hinder effective coordination and implementation involving the need to strengthen cooperation across ministries and local governments to drive area-based adaptation. A challenge remains in translating complex scientific data into clear public communication. Overcoming this is essential to build broad support among stakeholders and encourage real behavioral change.

2.3.4 Recommended priority actions, including regional cooperation

Thailand has a structured policy framework yet significant gaps remain between planning and implementation. The system struggles with institutional constraints and lacks specific strategies for Intensity Magnitude and Hybrid risk groups. To address high climate exposure the country must shift from reactive measures to a proactive risk governance model. Accordingly, the following priority actions are recommended.

1. Priority 1: Mainstream proactive risk governance and financing

The most critical gap is the reliance on reactive management. This is sustained by budget systems that allocate more funds to post-disaster relief than pre-disaster mitigation.

- Action Shift budget priorities. Adjust budget structure to focus on proactive risk reduction. Integrate climate adaptation and disaster prevention into key planning stages including the national budget process 13th NESDP implementation and provincial plans.
- Action Expand use of risk assessment models. Apply the study risk assessment model widely. The CRI methodology exemplifies applied risk assessment models required by the 13th NESDP. Quantifying specific risks provides data to justify proactive budget allocation. Future assessments must incorporate ocean literacy as a vulnerability indicator. Measuring public understanding is

critical as lower awareness reduces preparedness and conservation support increasing overall vulnerability.

2. Priority 2: Implement differentiated, area-based adaptation

The CRI analysis shows that risk varies significantly across different areas. Therefore, policy responses must be tailored to the specific risk profile of each province.

- For pure intensity risk groups e.g. Bangkok, Samut Songkhram actions focus on enforcing resilience standards. Require climate proofing for all new infrastructure and urban development to manage high concentration of socioeconomic pressure.
- For pure magnitude risk Groups e.g. Surat Thani, Songkhla prioritize large scale Ecosystem based Adaptation EbA. Invest in soft infrastructure like mangrove restoration and watershed protection to safeguard resource bases.
- For hybrid risk Group e.g. Chumphon, high intensity and magnitude requires comprehensive response. Combine targeted spatial planning with large scale resource management.

3. Priority 3: Strengthen transboundary and regional cooperation

Analysis confirms severe threats like tsunamis typhoons and droughts are transboundary and unmanageable alone. The 17 coastal provinces serve as the frontline making regional cooperation critical for domestic resilience.

- Action Enhance regional early warning systems. Improve data sharing and technical cooperation covering meteorological hazards through partnerships with ASEAN and typhoon committees. Address seismic and tsunami risks drawing on lessons from the 2004 disaster.
- Action Establish regional frameworks for shared resources. Manage shared marine ecosystems and fisheries sustaining local economies. Address transboundary environmental issues like marine pollution and oil spills impacting vulnerable coastal communities.
- Action Develop joint regional strategies. Collaborate to access international climate finance and technology converting shared goals into effective regional action.

2.4 Methodology and analysis

The Composite Risk Index (CRI) ranks risk across 17 Gulf of Thailand provinces based on the DPSIR framework. The model operates on the principle that Risk aggregates Pressure and Vulnerability mapping the interactions between socioeconomic trends and environmental conditions.

The Pressure Index (PI) comprises three pillars population dynamics density and economic pressure. The Vulnerability Index (VI) assesses social sensitivity through poverty and gender imbalance indicators. All metrics analyze data changes between 2000 and 2020.

Indicators measuring temporal change utilize Compound Annual Growth Rate CAGR. Density change was excluded to prevent statistical redundancy with population metrics. All data undergoes min-max normalization to a standard [0, 1] interval allowing aggregation of different units. Directionality is adjusted so higher values consistently indicate negative outcomes

The methodology applies equal weighting for calculation. The PI score averages its three pillars while the VI score averages its two indicators. The final CRI score results from the simple average of the calculated PI and VI scores.

The assessment utilizes two dimensions. The Intensity Score measures risk concentration regardless of physical size highlighting localized urban pressure. The Magnitude Score applies area weighting to reflect the total scale of resources and management workload. This dual analysis identifies three specific categories Intensity risk Magnitude risk and Hybrid risk.

Glossary

Composite Risk Index (CRI)	An index constructed by integrating metrics of risk magnitude and risk intensity to diagnose and rank the risk levels of coastal areas, which subsequently informs the prioritization of management measures.
DCCE	Department of Climate Change and Environment; the primary government agency in Thailand responsible for climate policy and environmental management.
Eastern Economic Corridor (EEC)	A special economic zone in eastern Thailand (Chonburi, Rayong, and Chachoengsao provinces) designed to be the nation's leading economic hub for trade, investment, and innovation.
EbA	Ecosystem-based Adaptation; the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change.
EM-DAT	Emergency Events Database; a global database on natural and technological disasters maintained by the Centre for Research on the Epidemiology of Disasters (CRED).
GDP	Gross Domestic Product; the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period.
GHG	Greenhouse Gas; gases in the earth's atmosphere that trap heat, such as carbon dioxide (CO_2) and methane (CH_4), contributing to the greenhouse effect.
GPP	Gross Provincial Product; the total economic value of all final goods and services produced within a specific province during a given period.
HDI	Human Development Index; a statistical composite index of life expectancy, education, and per capita income indicators, used to measure key dimensions of human development.
Hybrid Risk	A risk classification for areas that rank high in both risk magnitude and risk intensity, requiring the most integrated and comprehensive policy responses.

IHDI	Inequality-adjusted Human Development Index; an index that combines a country's average achievements in health, education, and income with how those achievements are distributed among the population.
Intensity Risk	A risk classification characterized by high economic density or concentrated asset value within a specific area (e.g., economic hubs), often requiring targeted spatial management.
Magnitude Risk	A risk classification characterized by the broad geographic scale or large population size exposed to potential hazards, often requiring broad resource planning.
NESDP	National Economic and Social Development Plan; Thailand's five-year national master plan for economic and social development.
Pressure Index (PI)	An index that measures the intensity of human activities and their potential negative impacts on natural resources and ecosystems, calculated in this study using population count, household count, population density, and Gross Provincial Product (GPP).
SDGs	Sustainable Development Goals; a collection of 17 interlinked global goals set by the United Nations to achieve a better and more sustainable future for all by 2030.
TMD	Thai Meteorological Department; the governmental agency responsible for weather forecasting and issuing warnings for hydrometeorological hazards in Thailand.
UNFCCC	United Nations Framework Convention on Climate Change; an international environmental treaty establishing a framework for intergovernmental efforts to address climate change.
Vulnerability Index (VI)	An index that measures the socioeconomic susceptibility of a population, calculated in this study using the poverty headcount ratio and sex ratio imbalance.

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Author contributions

Monissa Srisomwong: Data curation, formal analysis, methodology, visualization, writing-original draft, writing-review and editing,

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III. Pollution

Thailand's coastal and marine environments face mounting pressures from land-based pollution that threaten economic development, public health, and ecosystem integrity. Key pollution sources are industrial effluents, agricultural runoff, untreated domestic wastewater, and solid waste (notably plastics). The Upper Gulf of Thailand is the most critically affected area due to large riverine inflows that deliver high nutrient and organic loads, driving seasonal eutrophication, harmful algal blooms and hypoxic events that cause fish kills and aquaculture losses. The Eastern Economic Corridor (EEC) is a major hotspot for industrial and hazardous discharges. Annual municipal solid waste generation reached about 27.2 million tons in 2024, with only ~38% receiving proper disposal, sustaining high leakage of plastics to rivers and coasts.

These dynamics create clear social and economic impacts: reduced fisheries productivity, lost tourism revenue, elevated public health risk from contaminated seafood and bathing waters, and rising remediation costs. Existing monitoring shows that most marine waters retain beneficial quality, but persistent localized hotspots, data gaps (notably agricultural nutrient loading), and enforcement and infrastructure shortfalls present clear risks to future resilience.

3.1 Key Findings, Pollution Concerns, and National-Regional Significance

Thailand faces escalating environmental pressures from both land-based and marine pollution, which pose serious risks to economic development, public health, and ecosystem integrity. Pollution-related costs are estimated at 2 - 3% of GDP annually, driven by industrial effluents, agricultural runoff, untreated domestic wastewater, and plastic waste leakage.

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: Major Pollution Sources and Impacts

Pollution Category	Key Aspects	Primary Locations	Environmental & Socioeconomic Impacts
1. Nutrient & Organic Loading	- Untreated/partially treated municipal wastewater, industrial effluents, and agricultural runoff contribute to elevated levels of Biochemical	- Upper Gulf of Thailand (Bangkok vicinity, Chao Phraya River mouth) - Estuarine zones with high	- Hypoxia (low oxygen) events harming marine biodiversity - Fish kills and aquaculture losses - degraded water

Pollution Category	Key Aspects	Primary Locations	Environmental & Socioeconomic Impacts
	Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and nutrients (nitrogen, phosphorus). Seasonal eutrophication and algal blooms are common.	urban/agricultural discharge	quality affecting tourism
2. Solid Waste & Marine Litter	- ~27.2 million tonnes of municipal solid waste generated (in 2024 properly treated) - High plastics leakage from tourism and urban centers	- 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	- Coral reef and seagrass damage - Economic losses in tourism and seafood sectors - Long-term ecological degradation
5. High-Risk & Sensitive Areas	- Ecosystems and zones highly vulnerable to pollution	- Upper Gulf of Thailand - Rayong-Chonburi	Biodiversity loss, reduced climate resilience, threats to

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

Regional and Transboundary Dimensions

Thailand' pollution challenges have regional implications:

- **Gulf of Thailand**: As a semi-enclosed sea, nutrient enrichment and pollution accumulation affect 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 joint monitoring and response via COBSEA, ASEAN frameworks, and bilateral mechanisms

Strategic Implications

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 demands strengthened national infrastructure, improved enforcement, and regional cooperation to reduce nutrient loads, enhance waste management, 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. Limited spatial coverage and seasonal data hinder effective management. 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 show declining 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 nutrient fluctuations further increase ecosystem vulnerability.

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.

Marine ~~Coastal~~ Water Quality Status

Monitoring Network: 450 monitoring stations strategically positioned at varying distances from the shoreline (10, 100, and 500 meters) and 85 monitoring stations located 3 kilometers offshore from the shoreline. Quality classification results are divided into two areas: the Gulf of Thailand and the Andaman Sea as shown in Table 2- 4.

Table 2: Marine Water Quality Status (MWQS) in the Gulf of Thailand (10, 100, and 500 meters from the shoreline)

MWQS in the Gulf of Thailand at 10, 100, and 500 meters from the shoreline) (269 stations)		
Status	**%**	**Stations**
Excellent	2	5
Good	57	152
Fair	36	99
Poor	3	8
Very Poor	2	5

Table 3: Marine Water Quality Status (MWQS) in the Andaman Sea

MWQS in the Andaman Sea at 10, 100, and 500 meters from the shoreline) (181 stations)		
Status	**%**	**Stations**
Excellent	8	14
Good	64	116
Fair	26	48
Poor	2	3
Very Poor	0	0

Table 4: Marine Water Quality Status in the Gulf of Thailand (3 kilometers offshore from the shoreline)

MWQS in the Gulf of Thailand at 3,000 meters from the shoreline (85 stations)		
Status	**%**	**Stations**
Excellent	25	21
Good	67	57
Fair	7	6
Poor	1	1
Very Poor	0	0

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

The analysis of marine water quality over the past decade revels a decline in environmental conditions, as several measures parameters have surpassed the threshold set by the Marine Water Quality Standard **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

Over the past 10 years (2015–2024), marine water quality, as reflected by the Marine Water Quality Index (MWQI), has remained relatively stable. However, when examining individual parameters, nutrient-related parameters show increasing trends. In particular, total ammonia concentrations have tended to increase and exceed marine water quality standards, especially in river-mouth areas. Similar trends are observed for phosphate-phosphorus, as well as total coliform bacteria and fecal coliform bacteria, which also show increasing trends and exceed standards at certain monitoring stations and river-mouth areas.

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 Pollution (Domestic and Industrial Sources)

Thailand’s wastewater management system faces critical challenges in both domestic and industrial sectors. These challenges contribute directly to nutrient enrichment, chemical contamination, and microbial pollution in freshwater and coastal ecosystems.

3.1 Domestic Wastewater Management

Infrastructure and Coverage Status

As of 2024, Thailand operates 214 domestic wastewater treatment facilities with a combined annual capacity of 581.9 million cubic meters. However, the country generates approximately 2.5 million cubic meters of domestic wastewater daily—equivalent to over 912 million cubic meters annually. This means only 41% of domestic wastewater receives proper treatment, while 59% is discharged untreated or inadequately treated into rivers and canals. (PCD, 2024) *(https://dspot.pcd.go.th/)*

- **Coverage gap**: Nearly three-fifths of domestic wastewater remains untreated.

- **Urban–rural disparity**: Urban centers benefit from more developed infrastructure, while rural areas face limited-service provision.
- **Aging infrastructure**: Many existing facilities require upgrades and maintenance to maintain operational efficiency.

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.

In summary, environmental and public Health Impacts are as follows:

- Untreated wastewater contributes to elevated nutrient and pathogen loads in surface waters.
- Direct discharge into rivers and estuaries drives eutrophication, algal blooms, and hypoxic conditions.
- Coliform bacteria contamination near urban beaches poses health risks for recreational users and seafood consumers.

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.

Thus, industrial wastewater contains a complex mix of contaminants. These pollutants pose long-term risks due to persistence, bioaccumulation, and potential groundwater contamination.

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

Thailand continues to face systemic challenges in managing municipal solid waste (MSW), with growing volumes, uneven disposal quality, and persistent leakage into terrestrial and marine environments. In 2024, the country generated approximately 27.2 million tones of MSW—an increase of 0.9% from 2023—highlighting the need for scalable infrastructure, improved operational efficiency, and circular economy integration.

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 5: Key Performance Indicators of Municipal Solid Waste Situation

Management Category	Volume (Million Tonnes)	Percentage of Total	Description
Total Generated	27.20	100%	National MSW generation in 2024
Managed at Source	1.54	6%	Household composting, backyard burning, and other decentralized practices
Utilized Before Collection	6.02	22%	Informal recycling, source separation, and direct reuse
Collected by Authorities	19.64	72%	Formal municipal collection systems
Utilized After Collection	4.49	17%	Recovery at transfer stations and disposal sites
Final Disposal	15.15	55%	Waste requiring terminal treatment or disposal
- Proper Management	10.42	38%	Sanitary landfills, waste-to-energy, and compliant methods
- Improper Management	4.73	17%	Open dumping, uncontrolled burning, and unsuitable sites

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.

In summary, followings are key challenges and root causes

- **Low proper disposal rate**: Only 38% of MSW receives environmentally sound treatment. The remaining 17% is improperly disposed, contributing to land, air, and marine pollution.
- **Plastic leakage**: Urban centers and tourism hotspots generate large volumes of plastic waste, much of which enters waterways due to inadequate containment and recycling systems.
- **Informal sector dependence**: Informal waste pickers play a vital role in pre-collection recovery but operate without formal recognition or support.
- **Infrastructure gaps**: Many provinces lack access to sanitary landfills or modern waste-to-energy facilities, leading to reliance on open dumping.
- **Data and monitoring limitations**: Waste flow data is fragmented, and there is limited tracking of leakage pathways to coastal zones.

Table 6: Proposed Strategic Priorities for SAP Integration

Priority Area	Action	Indicator
Disposal Infrastructure	Construct regional sanitary landfills and MBT (Mechanical-Biological Treatment) hubs	% increase in properly disposed waste
Plastic Leakage Prevention	Implement Extended Producer Responsibility (EPR) for packaging and scale coastal cleanup programs	Reduction in plastic items per km of shoreline
Informal Sector Integration	Formalize and support informal recyclers through training, equipment, and incentives	Number of registered informal workers; volume recovered
Data & Monitoring	Establish national waste flow tracking system with leakage modeling to marine environments	Annual leakage estimates published; hotspot maps updated
Circular Economy	Promote reuse, recycling, and biodegradable alternatives through public campaigns and incentives	% of MSW diverted from disposal; % of plastic recycled

5) Hazardous Waste

Hazardous waste in Thailand is primarily generated by petrochemical, electronics, automotive, and manufacturing industries. Key waste streams include:

- Heavy metals (e.g., lead, mercury, cadmium, chromium)
- Persistent organic pollutants (POPs)
- Industrial solvents and by-products
- Medical and pharmaceutical waste

While large-scale industries often have in-house treatment or licensed disposal arrangements, small and medium-sized enterprises (SMEs) frequently lack the capacity or resources to manage hazardous waste safely.

- 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).

Management Challenges

- **Inadequate tracking**: Gaps in cradle-to-grave tracking systems hinder accountability and risk assessment.
- **Illegal dumping**: Improper disposal in unauthorized sites, particularly in peri-urban and rural areas, remains a concern.
- **Limited treatment capacity**: Existing hazardous waste treatment facilities are concentrated in a few regions, limiting access for remote provinces.
- **Weak enforcement**: Inspections and penalties for non-compliance are inconsistent, especially for SMEs.

6) Aquaculture Pollution

- **Coastal shrimp farming:** The government has set a limit of 500,000 rai (approximately 80,000 hectares) for coastal shrimp farming, with an annual production cap of 200,000 tonnes. As of 2022, more than 26,000 marine shrimp farms were in operation, producing an estimated 270,000 tonnes in 2024 — about 90% of which originated from coastal culture systems (Department of Fisheries, 2025).
- **Organic loading from feed waste:** Feed conversion ratios (FCR) in intensive shrimp farming systems typically range from 1.5 to 2.5:1. Only 20–30% of nitrogen and 10–15% of phosphorus in feed are assimilated into shrimp biomass, with the remainder released as waste. Phosphorus losses from aquaculture are estimated at 10,188 tonnes of P per year, accounting for 89% of total losses from the fisheries sector (Prathumchai et al., 2016).
- **Chemical use patterns:** Antibiotic use in shrimp farming was estimated at 500–600 metric tonnes (based on 1994 levels). Antibiotics have been detected in aquaculture wastewater at concentrations ranging from 3.36 to 85,000 ng/L. Commonly used chemicals include oxytetracycline, chloramphenicol, furazolidone, and various disinfectants (Sharma et al., 2021; Dierberg, 1996).
- **Pond discharge impacts:** Pond effluents contribute to water quality degradation through elevated levels of suspended solids, oxygen-demanding organic matter, and nutrients. Cumulative impacts arise from routine water exchange during grow-out phases, pond drainage at harvest, and illegal sediment disposal. Brackish-water aquaculture has also led to salinization of freshwater resources, while antimicrobial resistance genes have been detected in coastal aquaculture areas.

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 7: 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 originates from shipping activities, offshore drilling, and port operations, with over 240 recorded oil spill incidents since 1974, mainly concentrated in the Gulf of Thailand and the Andaman Sea.

Major incidents include:

- 2016 – Koh Samet: Approximately 50,000 liters of oil spilled near Ao Prao Beach, severely affecting local tourism and marine ecosystems.
- January 2022 – Map Ta Phut, Rayong Province: Around 47,000 liters of crude oil leaked near Map Ta Phut port, impacting coastal fisheries and beaches.
- September 2023 – Si Racha, Chonburi: Roughly 60,000 liters of oil spilled from a tanker, contaminating nearby marine waters.

In addition, since 2014, the Department of Marine and Coastal Resources (DMCR) has detected 44 unidentified oil spills, mostly along the eastern Gulf coast.

Response Capacity

Thailand's oil spill response framework is governed by the National Oil Spill Contingency Plan, B.E. 2545 (2002), which implements a tiered response system based on spill volume (Ministry of Transport, 2002):

- Tier 1: Spills of less than 20 tonnes, handled by local agencies.
- Tier 2: Spills of 20–1,000 tonnes, requiring national-level coordination and multi-agency involvement.
- Tier 3: Spills of over 1,000 tonnes, requiring international assistance.

Impact Zones

The Gulf of Thailand and the Andaman Sea remain the most impacted regions, with ecological risks peaking during high shipping seasons. Mangrove forests and coral reef ecosystems along the eastern Gulf coast are particularly vulnerable to oil contamination and long-term degradation

Table 8. Summary of Oil Pollution in Thailand

Incidents	Details	Volume / Extent
Total recorded oil spills since 1974	Multiple sources including shipping and offshore drilling	240+ incidents
2016 Koh Samet spill	Oil contamination at Ao Prao Beach	~50,000 liters
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	National contingency plan (Tier 1–3)	Tier 1: <20 t Tier 2: 20–1,000 t Tier 3: >1,000 t
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

3.3.1 Priority Transboundary Pollution Issues

Transboundary marine water quality issues in Thailand and the broader ASEAN region are primarily driven by nutrient pollution, alongside plastic pollution and other chemical contaminants. Nutrient pollution mainly originates from agricultural runoff, untreated domestic wastewater, and industrial effluents. Excessive nitrogen and phosphorus compounds transported through rivers and coastal waters cause eutrophication, leading to harmful algal blooms (HABs), oxygen depletion, and the degradation of marine ecosystems. Because these impacts extend across national boundaries, particularly in shared seas, they represent an inherently transboundary challenge for ASEAN member states.

According to the ASEAN Marine Water Quality Management report by the Pollution Control Department (PCD), coastal and estuarine waters throughout the region have experienced increasing nutrient loads due to expanding agriculture, urbanization, and aquaculture. The accumulation of nutrients and pollutants has been further intensified by population growth and industrial development, especially near river mouths and urban centers. The transboundary transport of nutrient-rich effluents via ocean currents, underscores the need for multinational governance and coordinated management (PCD, 2024).

In response, ASEAN member states have made nutrient pollution control a regional priority. Actions include the harmonization of water quality monitoring standards, data sharing, and the implementation of best practices for wastewater treatment and agricultural runoff reduction. Regional initiatives such as the Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) provide both technical guidance and governance frameworks to support these efforts. Key strategies emphasize integrated coastal zone management (ICZM), cross-country collaboration, and ecosystem-based approaches to restore and maintain marine water quality.

Further, China–ASEAN subregional cooperation on coral reef and marine ecosystem conservation incorporates nutrient pollution management within broader environmental goals. These initiatives also focus on blue carbon habitats—such as mangroves and seagrasses—that mitigate climate change while sustaining marine biodiversity. Bilateral partnerships, for example between China and Thailand, illustrate how targeted, scalable collaborations can effectively address nutrient and other marine pollution challenges, serving as models for wider regional application.

Overall, these insights highlight that nutrient pollution, as a key transboundary marine water quality threat, demands multilateral coordination, science-based policymaking, and effective enforcement mechanisms across ASEAN and its neighboring countries.

Marine Plastic Pollution:

Thailand ranks as the world's tenth largest marine plastic polluter, generating as estimated 1.03 million tonnes of mismanaged waste annually, of which nearly 0.41 million tonnes are discharged into the sea (TDRI, 2024). Marine debris, particularly plastic pollution, represents a major transboundary environmental issue for Thailand, intricately linked to broader regional waste management challenges in Southeast Asia. In 2023, approximately 882 tonnes of marine debris were recorded in the upper Gulf of Thailand, marking a substantial decline from 1,636 tonnes in 2022 (PCD, 2024). Single-use plastics—including food packaging, carrier bags, and thin plastic films—dominated the waste composition, reflecting prevalent consumption habits and inadequate waste management practices. The debris composition consisted of roughly 12% plastic fragments, 10% Styrofoam, 8% food wrappers, and 8% plastic bags, among other materials (TDRI, 2024).

Thailand is ranked as the sixth largest contributor to marine plastic debris globally, driven by a combination of factors including population growth, changing consumer lifestyle rising plastic production, economic expansion, and the growth of online shopping. The COVID-19 pandemic further intensified the problem, increasing plastic waste generation by approximately 15% nationwide, while Bangkok experienced a 62% surge, significantly worsening marine pollution (World Bank, 2023).

Marine plastic debris carried by ocean currents, crossing national boundaries and affecting marine ecosystems and coastal economies across the ASEAN region. The Thai government plays an active role in regional cooperation frameworks and ASEAN initiatives that aim to reduce marine plastic pollution through the promotion of a circular economy and the implementation of Extended Producer Responsibility (EPR) systems (World Bank, 2023).

Recent data indicate that single-use plastics continue to dominate marine debris along Thailand coastal region. According to the Pollution Control Department of Thailand

(2024), the most common types of plastic waste washing ashore include food bags, carrier bags, thin plastic films, and fragments of polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), and polyethylene terephthalate (PET). These materials primarily originate from consumer products and packaging reflecting prevalence of single-use plastics and improper disposal practices nationwide.

Marine plastic pollution remains a key environmental issue for the ASEAN region, with ongoing efforts to enhance regional cooperation (World Economic Forum, 2025). ASEAN has formally recognized marine plastic pollution as a transboundary environmental challenge and has established several collaborative frameworks to address it. The "Bangkok Declaration on Combating Marine Debris in the ASEAN Region" (2019) and the ASEAN Framework of Action on Marine Debris demonstrate the region's commitment to strengthening cooperation for marine environmental protection. These frameworks promote integrated policy approaches, harmonized regulations, data sharing, capacity building, and joint enforcement efforts aimed at reducing plastic leakage and other pollutants entering marine ecosystems (ASEAN Secretariat, 2024).

ASEAN regional cooperation efforts to combat marine plastic pollution have advanced rapidly, emphasizing collective action and sustainable plastics management. The ASEAN Conference on Combatting Plastic Pollution (ACCPP), established in 2023, serves as a central 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 under the theme "All Hands on Deck: Uniting Forces for a Sustainable Plastics Future." The conference highlighted the importance of multi-stakeholder collaboration, engaging governments, businesses, civil society, and academic institutions in advancing a unified regional approach to plastic pollution reduction.

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 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, resulting in significant environmental pollution risks and substantial economic costs. The plastics industry contributed approximately 7.7% of Thailand's GDP in 2021, with projected annual growth of over 5% until 2029, highlighting its economic significance despite the environmental challenges it poses (Earth Action, 2024).

To address pollution, the Thai government has introduced stringent policies, including a phased ban on plastic waste imports, which will be fully effective by 2025. This measure 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, indicating ongoing challenges in waste management infrastructure and public behavioral change (Earth Action, 2024).

The economic consequences of plastic pollution in Thailand are considerable. They include increased healthcare costs due to diseases linked to environmental contamination, losses in tourism revenue from degraded coastal waters, and higher expenditures for water treatment and environmental remediation by governments and businesses (PCD, 2024; ASEAN Secretariat, 2024). Long-term sustainability is at risk, as environmental degradation threatens economic stability and growth (World Bank, 2023).

These statistics underscore the urgency of strengthening waste management system , implementing effective policy, and fostering behavioral change to mitigate the economic and environmental impacts of plastic pollution 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.

Validated root causes and gaps

- Root cause: Insufficient wastewater treatment capacity and coverage (domestic). Evidence: 214 treatment facilities with ~581.9 million m3/yr capacity vs ~2.5 million m3/day generated; only ~41% of domestic wastewater treated. Implication: Direct discharge of untreated sewage into rivers and estuaries drives nutrient and pathogen loads.

- Root cause: Intensive fertilizer use without nutrient management. Evidence: Large imports of straight N and P fertilizers (2024 figures). No national quantification of N/P runoff. Implication: Agricultural runoff is a principal source of nutrient enrichment and eutrophication in coastal zones. Confidence:

- Root cause: High plastic and solid waste leakage due to limited final disposal capacity and informal handling. Evidence: 27.2 Mt MSW (2024) with only ~38% properly disposed and ~17% improperly disposed; substantial pre- and post-collection recovery but final disposal gap. Implication: Continued marine litter and microplastic inputs.

- Root cause: Industrial hazardous discharges concentrated in industrial estates (EEC), with variable compliance and limited enforcement capacity. Evidence: Hotspots in Rayong, Chonburi; mixed compliance across sectors; hazardous waste volumes specified. Implication: Localized contamination of sediments and seafood.
- Gap: Monitoring and data gaps for nutrient fluxes from agriculture and for emerging contaminants (antibiotics, microplastics, priority chemicals). Evidence: Draft explicitly states lack of official N/P runoff quantification and limited coverage for some pollutants. Implication: Limits ability to set reduction targets and track SAP outcomes.
- Gap: Institutional fragmentation and weak inter-agency coordination. Evidence: Multiple agencies with overlapping mandates; enforcement and penalization shortfalls reported. Implication: Inconsistent policy implementation and inefficient response to transboundary issues.
- Gap: Financing and economic incentives. Evidence: Budget constraints; private finance growing (e.g., green bonds) but not yet targeted to priority infrastructure. Implication: Insufficient capital for rapid infrastructure scale-up.

3.3.6 Recommended Priority Actions, Emphasizing Regional Cooperation

Immediate Actions (0-2 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 violation
4. Close critical monitoring gaps
   • Action: Design and fund a national nutrient loading assessment protocol and implement targeted monitoring in the Chao Phraya, Tha Chin, Mae Klong and Bang Pakong sub-catchments.
   • Indicator: Establishment of a national nutrient runoff dataset with quarterly estimates for main rivers within 24 months.
5. Prevent new leakage of plastics
   • Action: Enforce single-use plastic restrictions and accelerate roll-out of

Extended Producer Responsibility (EPR) systems for key packaging types.
• Indicator: EPR operational for top 5 packaging types; 20% reduction in reported coastal plastic items from beach surveys in two target provinces.

6. Tackle wastewater hotspots
   • Action: Prioritize construction/upgrading of decentralized sewage treatment for the top 10 coastal municipalities with repeated poor/fair readings.
   • Indicator: 10 target municipalities report >60% treatment coverage within two years.
7. Strengthen oil spill and emergency response
   • Action: Conduct joint Tier 1/2 oil spill response exercises in the Gulf and Andaman hotspots; map local clean-up assets.
   • Indicator: Two multi-agency exercises completed; local asset maps published.

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
4. Scale treatment and reduce nutrient loads
   • Action: Implement nutrient best management practice (BMP) programs for rice and intensive crops, combine with cost-share schemes for precision fertilizer application.
   • Indicator: 30% reduction in N and P loads from targeted sub-catchments versus baseline.
5. Improve industrial compliance and hazardous waste handling
   • Action: Implement real-time effluent monitoring (pilot in EEC), coupled with a permit reform requiring electronic reporting and stronger sanctions.
   • Indicator: 80% compliance rate among large industrial facilities in EEC; reduction in detected priority pollutant exceedances by 50% at sentinel stations.
6. Upgrade solid waste infrastructure
   • Action: Build regional sanitary landfill/MBT hubs, formalize informal recyclers with incentives, and scale municipal recycling targets.
   • Indicator: Proper disposal rate increased from 38% to 60%; informal sector integrated in at least 3 regional hubs.

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
3. Institutionalize integrated coastal management and regional cooperation
• Action: Establish inter-ministerial SAP steering body with provincial representation and a regional coordination mechanism with COBSEA/ASEAN for shared monitoring and response.
• Indicator: SAP steering body operational; bilateral/regional data-sharing MoUs signed and implemented.
4. Move to circular economy
• Action: Incentivize industrial symbiosis, national roadmap for plastic circularity and biodegradable alternatives, and scale green finance instruments for environmental infrastructure.
• Indicator: National plastics circularity target met (e.g., 70% recycled/avoided by 2035); green finance flows > X billion THB to SAP projects

Monitoring, verification and adaptive management (for SAP reporting)

- Core SAP indicators (recommended, measurable and reportable annually):
    - Percent of domestic wastewater treated nationally and for priority coastal municipalities.
    - N and P loads (tonnes/year) from major river basins draining to the Gulf and Andaman Sea.
    - Tonnes of mismanaged plastic leakage to marine environment (modelled and shoreline survey corroboration).
    - Number and volume of industrial effluent exceedances at sentinel sites.
    - Area of degraded sensitive habitats (coral, seagrass, mangrove) recovered or stabilized.
- Monitoring design:
    - Combine fixed station water quality monitoring (PCD/DMCR) with targeted catchment monitoring for nutrient fluxes (grab + automated samplers), periodic citizen science beach litter surveys, and sentinel biota sampling for microplastics.
    - Use data framework and require metadata and QA/QC documentation for all datasets.
- Verification and adaptive management:
    - Annual SAP progress review with independent technical audit every 3 years to recalibrate targets, budgets and interventions.
    - Use a learning cycle: Plan → Implement → Monitor → Evaluate → Adjust.

3.4 Methodology and Analysis

This assessment adopts a comprehensive multi-media approach to examine pollution across both land-based and marine environments. The methodology integrates quantitative environmental monitoring data with qualitative institutional and policy analysis to provide an in-depth understanding of Thailand's pollution challenges, sources, and existing management responses.

A source-pathway-receptor framework is applied to identify key pollution sources, transport mechanisms, and environmental and human receptors. Risk-based prioritization is used to focus the assessment on pollution issues with the greatest potential environmental and public health impacts, while also incorporating environmental, social, and economic dimensions to support sustainable development and informed decision-making.

The assessment integrates multiple spatial and temporal scales. Pollution impacts are analyzed at local, national, and regional levels to support hotspot identification, policy formulation, and transboundary cooperation. Temporal analysis combines historical trend assessment—using indicators such as the Marine Water Quality Index (MWQI)—with current status evaluation to establish baseline conditions and support future scenario development for planning and risk management.

Data collection draws on both primary and secondary sources. Primary data include marine and coastal water quality monitoring from national networks operated by relevant environmental agencies, as well as pollution source data from industrial monitoring, waste generation surveys, and agricultural activity assessments. Secondary data are obtained from government databases and sectoral ministries, providing socioeconomic, industrial, agricultural, and transportation information, as well as historical environmental datasets to support trend and impact analysis.

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IV. Ecosystems

4.1 Key Findings

Thailand's coastal and marine ecosystems comprising mangroves, coral reefs, and seagrass meadows are the foundation of the country's coastal resilience and blue economy. The assessment across the five focal sites (Welu River Estuary, Bandon Bay, Pak Phanang Bay, Samut Prakan, and Don Hoi Lot) reveals a mosaic of ecological conditions, demonstrating both significant conservation success and persistent management challenges.

Mangroves occupy approximately 480.7 km² (18.4%) of the total wetland area (2,613.7 km²). The most extensive stands are found in Bandon Bay (255.7 km²) and Pak Phanang Bay (90.0 km²), while smaller but ecologically crucial tracts remain in Samut Prakan and Don Hoi Lot. Species diversity is high (17–30 species), dominated by *Rhizophora apiculata*, *R. mucronata*, and *Avicennia alba*. The occurrence of rare and globally threatened species *Bruguiera hainesii*, *Sonneratia griffithii* (CR), and *Heritiera fomes* (EN) underscores Thailand's international conservation importance. Mangrove condition varies by site: natural and well-conserved (>65%) in Pak Phanang and Don Hoi Lot, but moderately managed (~47%) in Welu. Restoration and replanting programs led by DMCR and community networks have successfully reversed historic declines (up to 60% loss since the 1970s). These areas now provide vital shoreline stabilization, nursery habitats, and substantial blue carbon storage, with estimated carbon stocks of 0.25–2 million tonnes C per site.

Coral reefs show strong spatial contrasts between offshore and nearshore conditions. Offshore reefs at Koh Losin (69.5% live coral) and Koh Tao (61.3%) are in good to excellent condition, characterized by high biodiversity, complex reef structures, and strong tourism potential. In contrast, nearshore reefs such as Koh Kood, Koh Mak, and Koh Si Chang exhibit moderate degradation (29–39% live coral) from sedimentation, nutrient loading, and recreational impacts. Dominant massive coral forms (*Porites*, *Dipsastraea*, *Platygyra*) indicate structural resilience, yet recurrent bleaching events and land-based runoff continue to suppress recovery rates. Offshore pinnacles in Chumphon Province host diverse coral assemblages (55–68% live cover) and function as key larval source zones linking shallow and deep reef habitats, suggesting high ecological connectivity and potential for inclusion in OECM networks.

Seagrass cover roughly 25 km², concentrated in Bandon Bay (12.74 km²) and Chumphon (11.64 km²). Dominant species include *Enhalus acoroides*, *Thalassia hemprichii*, *Halodule uninervis*, and *Halophila ovalis*. These habitats serve as critical nurseries for juvenile fish and crustaceans, feeding grounds for dugongs, and major carbon sinks with high productivity and sediment stabilization capacity. Despite their importance, seagrass meadows remain vulnerable to turbidity, nutrient runoff, boat anchoring, and coastal reclamation, leading to habitat fragmentation and loss of connectivity with coral and mangrove systems. The Bandon Bay complex, however, remains a national model for blue carbon monitoring and community-based restoration.

The interconnected ecosystems of mangroves, coral reefs, and seagrasses face multiple cumulative pressures:

- Aquaculture expansion and urbanization causing habitat conversion.
- Eutrophication and chemical pollution degrading coral and seagrass habitats.
- Coastal erosion and climate-driven sea-level rise impacting mangrove zonation.
- Thermal anomalies and bleaching events reducing coral diversity and cover. These stressors collectively weaken ecological connectivity and reduce ecosystem resilience, particularly where watershed–coast interactions remain unmanaged. Integrated land–sea governance and pollution control are therefore critical to sustaining ecosystem functions.

Ecosystem Services and Blue Economy Contribution: Combined annual ecosystem service values across the focal sites are estimated at US$17–32 million per site, encompassing fisheries, tourism, shoreline protection, and carbon storage.

- Mangroves and seagrass meadows contribute significantly to blue carbon markets through measurable carbon sequestration.
- Coral reefs support marine tourism, biodiversity conservation, and fisheries productivity.

Estimated blue carbon storage ranges from 0.25 to 2 million tonnes of carbon (C) per site, underscoring their critical role in Thailand's climate mitigation commitments.

Thailand's progress in mangrove rehabilitation, coral restoration, and seagrass monitoring demonstrates a strong foundation for Integrated Coastal Management (ICM) and Nature-based Solutions (NbS). However, management fragmentation and enforcement gaps persist. To ensure long-term ecosystem resilience and socio-economic benefits, Thailand should:

1. Strengthen institutional coordination among DMCR, DNP, DOF, and provincial agencies.
2. Scale up blue carbon initiatives and establish verified carbon credit schemes.
3. Integrate land–sea connectivity into watershed planning and coastal zoning.
4. Expand OECM and community-based restoration programs to enhance local stewardship.
5. Mobilize sustainable financing through eco-certification, community ecotourism, and payment for ecosystem services (PES).

Thailand's coastal ecosystems collectively represent a living natural infrastructure supporting biodiversity, food security, and climate resilience. By linking science-based management, community participation, and sustainable financing, Thailand can solidify its leadership in the ASEAN region under global frameworks such as the Ramsar Convention, BBNJ Agreement, and UN SDGs 13, 14, and 15 advancing a nature-positive, climate-resilient, and inclusive blue economy.

4.2 Current status by ecosystem and by indicator group

4.2.1 Mangroves and Wetlands

Mangrove and wetland ecosystems along the Gulf of Thailand play a critical role in sustaining biodiversity, regulating hydrological processes, and supporting coastal livelihoods. The five focal sites Welu River Estuary, Bandon Bay, Pak Phanang Bay, Samut Prakan, and Don Hoi Lot illustrate the diversity of Thailand's coastal landscapes, from industrialized estuaries to intact Ramsar-listed wetlands. Together they cover 2,613.68 km², including 480.69 km² of mangroves, accounting for 18.4% of total wetland area. These ecosystems provide multifunctional services, including nursery grounds for fisheries, shoreline stabilization, carbon sequestration, and cultural values for local communities. Their overall health, however, varies widely according to the degree of human influence, catchment management, and conservation policy enforcement.

Biological Condition and Diversity

The extent of mangrove forests reflects a gradient of anthropogenic impact:

- Welu River Estuary: 72.06 km² (52.7% natural; 47.3% managed) under local community reforestation schemes.
- Bandon Bay: 255.70 km² (63–77.5% natural) interspersed with shrimp ponds and shellfish farms.
- Pak Phanang Bay: 90.00 km² (≥65% natural) in the Lower Songkhla watershed.
- Samut Prakan: 33.74 km², highly fragmented due to industrial zones and land reclamation.
- Don Hoi Lot: 29.19 km² of largely natural mangrove and mudflat systems forming an ecologically intact Ramsar wetland.

Species Richness

A total of 30 mangrove species were recorded nationwide.

- Khlong Dan (Samut Prakan) supports 30 species, representing the highest species richness.
- Welu Estuary and Bandon Bay host 24–26 species each.
- Endangered species such as *Bruguiera hainesii*, *Sonneratia griffithii*, and *Heritiera fomes* highlight the global conservation significance of Thailand's mangrove flora.

The structure is dominated by *Rhizophora apiculata*, *R. mucronata*, *Avicennia alba*, *Lumnitzera racemosa*, and *Excoecaria agallocha*. Rooted vegetation provides substrate stability and supports nursery functions for crustaceans and juvenile fish.

Indicator-Based Assessment

- Vegetation cover and canopy density remain highest in Pak Phanang and Don Hoi Lot, indicating strong natural regeneration and low disturbance.
- Soil organic carbon levels average 80–150 tonnes C/ha, corresponding to high blue carbon potential.
- Hydrological connectivity is moderately impaired in Welu and Bandon Bays due to embankments and aquaculture dikes, while tidal flushing remains intact in Don Hoi Lot.
- Biodiversity indices suggest medium to high species evenness (Shannon–Wiener index 2.0–2.8) in natural zones but decline sharply (<1.5) in managed aquaculture areas.

Pressure Indicators

Key pressures across sites include:

1. Aquaculture expansion and conversion (most severe in Welu and Bandon Bay).
2. Pollution from agriculture and industry, including nutrient and heavy-metal contamination in Samut Prakan.
3. Coastal erosion and sediment imbalance notably in Pak Phanang and Welu due to reduced riverine sediment flow.
4. Overharvesting and mangrove cutting for fuelwood in rural zones.
5. Tourism infrastructure development around Don Hoi Lot's tidal flats.

Responses have been implemented at national and local scales:

- DMCR's National Mangrove Rehabilitation Program (2014–2024) restored over 80 km² across surveyed provinces.
- Community co-management groups in Welu and Bandon Bays lead local monitoring, seedling nurseries, and carbon accounting.
- Eco-restoration projects under the "Reversing Environmental Damage" framework have promoted mangrove planting integrated with aquaculture ("silvo-fishery" systems).
- Protected area designations such as Don Hoi Lot's Ramsar status (No.1099) and Pak Phanang's provincial conservation zones have strengthened legal protection.

Trends, Dynamics, and Drivers

Internal (Intrinsic) Drivers

- Sediment redistribution and salinity variation influence mangrove zonation and regeneration.
- Natural regeneration rates are high in Don Hoi Lot but slow in industrial areas.
- Monsoonal patterns drive periodic flooding that enhances productivity but may limit propagule establishment.

External (Extrinsic) Drivers

- Watershed modification (dams, irrigation, dikes) alters freshwater flow and sediment supply.
- Climate change intensifies erosion, sea-level rise, and storm surges.
- Urbanization replaces wetlands with built-up zones, notably in Samut Prakan.
- Shrimp-farm effluents lead to nutrient loading and algal blooms in enclosed bays.

These drivers collectively contribute to fragmentation, hydrological disconnection, and biodiversity loss, reducing the resilience of mangrove–wetland systems.

Socio-Economic and Ecosystem Service Values

Mangroves and wetlands deliver multiple ecosystem services valued between US$17–32 million per site annually, including:

- Fisheries production (up to 60% of coastal fishery yields depend on mangrove nursery habitats).
- Coastal protection, reducing wave energy by 60–80%.
- Carbon sequestration: 250,000–2,000,000 tonnes of carbon per site (equivalent to US$2–14 million/year).
- Cultural and ecotourism benefits, such as the mudflat ecotourism at Don Hoi Lot and mangrove trails in Bandon Bay.

However, monetization of ecosystem services remains limited, requiring standardized national valuation methods and integration into blue carbon credit frameworks under Thailand's Nationally Determined Contributions (NDCs).

Governance and Management Performance

The Department of Marine and Coastal Resources (DMCR) leads national mangrove management through Integrated Coastal Management (ICM) strategies, supported by provincial administrative organizations and local communities. Despite progress, gaps persist:

- Fragmented monitoring responsibilities among DMCR, DNP, and local authorities.
- Inconsistent application of environmental impact assessments (EIAs) for coastal projects.
- Limited enforcement capacity against illegal aquaculture encroachment.
- Need for participatory and gender-sensitive community engagement in co-management.

Co-management success stories include:

- Welu Estuary Community Forest Group, which reforested >300 ha since 2015 and established carbon monitoring.
- Bandon Bay Fishermen's Network, which integrated blue carbon monitoring into local tourism enterprises.
- Don Hoi Lot Ramsar Committee, involving DMCR, local authorities, and shellfish collectors in adaptive management.

Cross-Cutting Issues and Recommendations

1. Enhance Integrated Land–Sea Planning: Link watershed management with coastal ecosystem restoration to reduce sediment and pollution stress.
2. Institutionalize Blue Carbon Accounting: Establish standardized methodologies for carbon monitoring and inclusion in national GHG inventories.
3. Develop Sustainable Financing: Leverage green and blue funds for restoration (e.g., Thailand Climate Change Fund, GCF readiness projects).
4. Expand Community-Based Monitoring: Support citizen science initiatives to improve spatial data on species, hydrology, and carbon.

5. Strengthen Legal Frameworks: Update the Mangrove Management Master Plan (2025–2035) to align with the BBNJ Agreement and SDG targets.
6. Integrate Restoration with Livelihoods: Promote silvo-fishery systems, eco-tourism, and blue carbon offsetting to align local benefits with conservation outcomes.

Thailand's mangrove and wetland ecosystems are ecologically diverse, socially significant, and economically productive yet increasingly vulnerable to cumulative anthropogenic pressures and climate stressors. The five focal sites (Welu River Estuary, Bandon Bay, Pak Phanang Bay, Samut Prakan, and Don Hoi Lot) collectively represent the full spectrum of coastal ecosystem conditions in the Gulf of Thailand, ranging from relatively intact natural systems to highly modified industrial estuaries.

Overall, the condition indicators show that mangrove cover and biodiversity have stabilized or improved modestly in most areas due to reforestation, policy interventions, and community-based management. Pressure indicators, however, reveal persistent challenges: habitat fragmentation, water pollution, sediment imbalance, and urban encroachment. Despite restoration gains, external watershed drivers and climate-related sea-level rise continue to erode long-term resilience.

Economically, the assessed mangrove and wetland systems yield combined ecosystem service values exceeding US$100 million per year, underscoring their importance for national blue economy development, carbon neutrality, and disaster risk reduction. Yet these values are seldom internalized into planning or investment decisions. Strengthening the policy–finance–science interface will be key to unlocking the full potential of these ecosystems as natural climate assets.

From an institutional perspective, Thailand has made notable progress under the Department of Marine and Coastal Resources (DMCR) through Integrated Coastal Management (ICM) frameworks, the Mangrove Management Master Plan, and partnerships with local governments and communities. However, implementation remains uneven. Improved data sharing, clearer jurisdictional mandates, and enhanced monitoring capacity are urgently needed.

At the community level, local networks in Welu and Bandon Bays demonstrate successful co-management through silvo-fishery, eco-restoration, and blue carbon pilot projects, serving as replicable models for scaling nationwide. The experience from Don Hoi Lot also highlights the value of participatory monitoring in sustaining Ramsar sites under multiple-use regimes.

Looking ahead, sustaining mangrove and wetland resilience in Thailand will require a paradigm shift from restoration to regeneration, embedding these ecosystems into climate adaptation, carbon markets, and socio-economic development. A set of strategic priorities emerges from this assessment:

1. Mainstream Nature-based Solutions (NbS) and Blue Carbon mechanisms into national climate and tourism strategies to secure long-term financing.
2. Institutionalize ecosystem accounting under Thailand's Ocean Accounts framework, linking biodiversity and carbon metrics to investment outcomes.
3. Enhance community empowerment through decentralized governance, capacity building, and equitable benefit-sharing mechanisms.
4. Foster regional cooperation under ASEAN and BBNJ frameworks to protect transboundary mangrove–wetland corridors and migratory bird habitats.

5. Expand research–policy integration, especially on ecosystem thresholds, hydrological restoration, and socio-economic valuation.

In conclusion, Thailand's mangroves and wetlands are at a pivotal moment. They have demonstrated ecological recovery and community resilience but remain under pressure from rapid development and climate uncertainty. Achieving sustainable outcomes will depend on the nation's ability to connect science, governance, and finance—transforming mangroves and wetlands from degraded resources into living infrastructures for a climate-resilient, carbon-neutral, and nature-positive future.

4.2.2 Coral Reefs and Seagrasses

Coral reefs and seagrass meadows in the Gulf of Thailand are among the nation's most productive and ecologically significant coastal ecosystems, providing the foundation for biodiversity, fisheries, and coastal protection. These ecosystems offer essential services such as nutrient cycling, carbon sequestration, and shoreline stabilization, while serving as critical nurseries for fish and invertebrates. Their condition varies considerably across spatial gradients, reflecting differences in exposure to human pressures, geomorphology, and hydrodynamic settings.

Across the Gulf, coral reefs and seagrasses exhibit strong spatial gradients in condition, resilience, and exposure to human pressures:

- Offshore coral reefs particularly Koh Losin, Koh Kra, and Koh Tao, remain in healthy to remarkably healthy condition, with live coral cover ranging from 59.5–69.5% and high proportions of massive and branching corals such as *Acropora*, *Porites*, and *Montipora*. These reefs exhibit strong structural complexity, high fish biomass, and limited sedimentation due to clear oceanic waters and low anthropogenic stress. Koh Losin, in particular, demonstrates outstanding resilience, with minimal algal overgrowth and stable coral–fish trophic structures. These offshore systems are key larval sources and biodiversity reservoirs, critical to maintaining Gulf-wide ecological connectivity.
- Underwater pinnacles in Chumphon Province represent unique offshore habitats characterized by 31.1% live coral cover, 27.2% dead coral, and 23.8% rocky substrate, indicating a moderately disturbed yet resilient ecosystem. Dominant taxa include *Porites lutea*, *Platygyra sinensis*, *Favia favus*, and *Dipsastraea pallida*, which form dense coral gardens along slopes at depths of 15–25 meters. These pinnacles support abundant reef fish assemblages and function as ecological linkages between coastal and deep reef systems, facilitating larval dispersal across the Gulf of Thailand. Although past disturbances such as coral bleaching and anchor damage have occurred, the reefs demonstrate high recovery potential under effective management. The site's geomorphology and current regimes promote coral recruitment, making it a critical area for sustaining long-term reef resilience and contributing to blue carbon storage.
- Nearshore reefs at Koh Si Chang (29.2%), Koh Lan (39.5%), Koh Mak (29.7%), and Koh Kood (33.5%) exhibit moderately healthy to degraded conditions, with substantial proportions of dead coral and sandy substrate. These patterns reflect chronic sedimentation, eutrophication, and physical damage associated with coastal tourism and dredging activities. Reefs near Laem Chabang and Si

Racha experience particularly high sediment and pollution loads, microplastic contamination (0.02–42.46 particles/m³), and recurrent coral bleaching events, notably in 2010 and 2020. Although coral restoration initiatives such as coral nurseries and artificial reef modules have been implemented by the Department of Marine and Coastal Resources (DMCR) and local universities, natural recovery remains constrained by persistent turbidity and thermal stress. Continuous monitoring, coupled with effective land-based pollution management, is essential to enhance the resilience and recovery potential of these nearshore reef systems.

- Seagrass habitats are concentrated in Ban Don Bay (12.74 km², ~30% coverage) and Chumphon (11.64 km², ~27% coverage), dominated by *Enhalus acoroides*, *Thalassia hemprichii*, *Halodule uninervis*, and *Halophila ovalis*. These meadows function as blue carbon sinks, nursery grounds for dugongs, sea turtles, and juvenile fish, and sediment stabilizers. Chumphon's meadows, extending across 8,000–10,000 hectares, fall partly within Mu Ko Chumphon National Park (IUCN II) and are managed as multiple-use zones under DMCR supervision. While generally stable, these seagrass systems face localized degradation from nutrient enrichment, aquaculture expansion, and boat propeller scarring. Restoration and monitoring are strengthened by community-based programs and blue carbon initiatives contributing to Thailand's Nationally Determined Contributions (NDCs) for climate mitigation.Collectively, coral reefs, underwater pinnacles, and seagrass meadows form an interconnected ecological network. The offshore reefs and pinnacles act as biodiversity reservoirs and larval sources, while nearshore reefs and seagrass beds provide critical habitat functions for fisheries and local livelihoods. Maintaining these linkages is essential for sustaining ecosystem resilience, blue carbon potential, and the ecological integrity of the Gulf of Thailand.

Condition Indicators

The biological condition of coral reefs and seagrass ecosystems in the Gulf of Thailand demonstrates clear spatial heterogeneity, shaped by water quality, geomorphology, and anthropogenic pressures. Overall, offshore ecosystems exhibit strong ecological integrity and resilience, while nearshore habitats remain under stress from sedimentation, pollution, and tourism activities.

Coral Reefs

- Live Coral Cover: Coral cover ranges from 29% at Koh Si Chang—classified as degraded—to nearly 70% at Koh Losin, representing a healthy to remarkably healthy reef state. Offshore reefs such as Koh Kra and Koh Losin maintain structurally complex coral frameworks dominated by branching and massive forms of *Acropora*, *Porites*, and *Montipora*, supporting diverse fish assemblages and invertebrate communities.In contrast, nearshore reefs (Koh Si Chang, Koh Lan, Koh Mak) show a high proportion of dead coral and sand substrates (30–45%), with visible algal dominance and reduced coral recruitment rates.
- Dominant Genera and Functional Composition: Major coral taxa include *Acropora*, *Porites*, *Montipora*, *Pocillopora*, *Dipsastraea*, *Favia*, and *Platygyra*. These genera form the core reef-building community and contribute to the structural and functional diversity of reef ecosystems. Offshore assemblages

are more diverse and resilient, while nearshore assemblages are increasingly dominated by stress-tolerant species such as *Porites lutea* and *Favia favus*.

- Reef Structure and Complexity: Offshore sites, particularly Koh Kra, Koh Losin, and underwater pinnacles in Chumphon Province, exhibit high vertical relief (15–25 m), well-developed reef slopes, and extensive crustose coralline algae. These physical structures enhance coral larval settlement and habitat complexity. Nearshore reefs, however, are characterized by turbid, sediment-laden waters, leading to flatter topography and lower benthic diversity.
- Bleaching and Recovery Dynamics: Thailand's reefs experienced major bleaching events in 2010, 2016, and 2024. While offshore reefs showed rapid recovery within 1–2 years due to strong water circulation and deeper refugia, nearshore reefs suffered partial mortality and slow regeneration. Recent DMCR surveys indicate that coral cover at Koh Kra and Koh Losin has returned to near pre-bleaching levels, whereas recovery at Koh Si Chang and Koh Lan remains incomplete due to recurring heat stress and sedimentation.

Seagrass

- Species Composition and Distribution: Dominated by *Enhalus acoroides*, *Thalassia hemprichii*, *Halodule uninervis*, and *Halophila ovalis*, seagrass meadows in Ban Don Bay (12.74 km²) and Chumphon (11.64 km²) form extensive habitats critical for marine megafauna such as dugongs and sea turtles. These meadows are typically found in shallow, sheltered bays influenced by estuarine inflows.
- Coverage, Density, and Biomass: Ban Don Bay supports Thailand's largest continuous meadow, with seagrass cover reaching up to 30% in core zones. In contrast, Chumphon's meadows are patchy but dense, often exceeding 27% coverage in localized areas. Average biomass values range between 400–800 g DW m^{-2}, depending on species dominance and sediment characteristics.
- Carbon Stock and Blue Carbon Role: Estimated carbon stocks are 35–60 tonnes C ha^{-1}, placing these meadows among Thailand's most important blue carbon ecosystems. Seagrass areas in Chumphon and Ban Don Bay are integrated into Thailand's National Blue Carbon Assessment, contributing to national GHG accounting and carbon offset initiatives.
- Ecological Function: Seagrasses act as sediment traps and nutrient filters, stabilizing shorelines and maintaining water clarity. They serve as nursery habitats for commercially valuable species such as juvenile groupers, shrimps, and blue swimming crabs. The health of these meadows directly supports the productivity of adjacent coral reef and mangrove systems.

Pressure Indicators

Coral and seagrass ecosystems face multifaceted pressures:

1. Sedimentation and Erosion: Land-based runoff, dredging, and coastal construction reduce light penetration and smother benthic communities, particularly near Laem Chabang, Si Racha, and Ban Don Bay.
2. Nutrient and Chemical Pollution: Agricultural and aquaculture effluents elevate nitrogen and phosphorus, promoting algal overgrowth on reefs and seagrass leaves.

3. Tourism Impacts: Anchoring, trampling, and wastewater discharge from resorts and boats are chronic stressors in Koh Si Chang, Koh Lan, and Koh Mak.
4. Thermal Stress: Elevated sea-surface temperatures and bleaching events (2010, 2016, 2024) have caused up to 50% coral mortality in vulnerable areas.
5. Overfishing and Physical Damage: Destructive gear (nets, traps) causes coral breakage and disturbs seagrass beds, especially near artisanal fishing grounds.
6. Microplastic Pollution: Concentrations up to 40–45 particles/m³ recorded near Koh Si Chang and Ban Don Bay indicate ongoing contamination risk.

Cumulative impacts from these pressures result in reduced resilience, particularly in transitional zones where coral and seagrass habitats overlap.

Response Indicators

Thailand has demonstrated significant policy and practical responses at multiple scales:

- National Frameworks:
    - Implementation of the Marine and Coastal Resources Management Master Plan (2023–2030) under DMCR.
    - Integration of coral reef and seagrass monitoring within the National Blue Carbon Program and NDC implementation plan.
- Protected Areas and Site Management:
    - Mu Ko Chumphon National Park, Koh Kra, and Koh Losin designated as biodiversity hotspots.
    - Marine zoning introduced to regulate tourism, aquaculture, and fishing activities.
- Community and Local Initiatives:
    - Seagrass replanting projects in Ban Don Bay and Chumphon involving local fishers and NGOs.
    - Coral nurseries and eco-mooring systems reducing anchor damage in Koh Tao and Koh Mak.
    - Citizen science programs (Reef Watch, Seagrass Guardians) improving public participation and data collection.
- Scientific and Regional Collaboration:
    - Continuous coral monitoring by DMCR, Chulalongkorn University, and the Southeast Asian Fisheries Development Center (SEAFDEC).
    - Partnerships with UNEP and ACB (ASEAN Centre for Biodiversity) to strengthen regional resilience networks.

Trends and Outlook

- Coral Reefs: Offshore reefs show stabilizing or improving trends, particularly at Koh Kra and Koh Losin, where high water quality and low human pressure prevail. Nearshore reefs exhibit declining trends due to chronic stress, with some localized recovery from coral gardening and artificial reef installation.

- Seagrasses: Coverage in Ban Don Bay and Chumphon has declined by ~25% from historical baselines, mainly due to sedimentation and eutrophication. However, adaptive restoration and improved community stewardship have led to localized regrowth.
- Climate Resilience: Offshore ecosystems demonstrate high potential for recovery post-disturbance, but increasing sea-surface temperatures, acidification, and coastal development could offset these gains without adaptive management.

Future trajectories depend on pollution control, marine spatial planning, and integrated coral–seagrass restoration efforts at the landscape scale.

Assessment by Indicator

Coral reefs and seagrass ecosystems in the Gulf of Thailand exhibit coral cover ranging from 30–70%, with offshore reefs remaining healthy and nearshore reefs showing degradation, while seagrass beds remain stable in deeper zones. Overall trends indicate stable to improving conditions offshore but declining nearshore due to increasing human pressures.

The main pressures affecting these ecosystems include sedimentation, pollution, coral bleaching, and tourism-related impacts, all of which are intensifying around urban and industrial coastal hubs.

Management responses led by the Department of Marine and Coastal Resources (DMCR), marine parks, and local communities have been expanding and increasingly effective, focusing on restoration, monitoring, and enforcement.

Ecological connectivity between coral reefs and seagrass meadows remains strong and critical for fisheries and biodiversity, yet it is moderate and declining in fragmented areas. To maintain these linkages, it is vital to expand marine protected area (MPA) networks and enhance integrated management.

Key priorities therefore include expanding monitoring and habitat protection, strengthening land–sea integration and regulation of coastal activities, securing long-term funding, and maintaining ecological corridors through effective MPA expansion and blue-carbon initiatives.

Coral reefs and seagrass meadows in the Gulf of Thailand exhibit a complex mosaic of degradation and recovery, shaped by natural processes and human interventions. Offshore ecosystems, including Koh Kra, Koh Losin, Koh Tao, and underwater pinnacles in Chumphon Province, retain high ecological integrity with coral cover exceeding 60%, diverse benthic communities, and healthy fish assemblages. These areas serve as biodiversity reservoirs and larval sources, supporting regional connectivity across the Gulf. In contrast, nearshore habitats such as Koh Si Chang, Koh Lan, and Ban Don Bay remain under severe stress from sedimentation, nutrient enrichment, and coastal development. The continued decline in nearshore water quality has weakened coral–seagrass linkages, reduced fish nursery capacity, and heightened vulnerability to climate-induced disturbances.

Despite these pressures, Thailand's integrated management frameworks anchored in science-based monitoring, blue carbon initiatives, and community engagement have provided a foundation for resilience. The Department of Marine and Coastal Resources (DMCR), together with universities and local communities, has expanded long-term coral and seagrass monitoring, restored degraded habitats, and implemented eco-mooring, coral nurseries, and seagrass replanting programs. These actions have led to measurable recovery in offshore reefs and localized improvements in seagrass density in Ban Don Bay and Chumphon. Importantly, national policies now recognize coral reefs and seagrasses as natural climate solutions (NCS) contributing to Thailand's Nationally Determined Contributions (NDCs) under the Paris Agreement.

To sustain progress, Thailand must strengthen land–sea connectivity, ensuring that watershed management, coastal zoning, and marine spatial planning are harmonized to minimize land-based pollution and sedimentation. Institutionalizing blue carbon accounting is critical to valuing these ecosystems within national greenhouse gas inventories and climate financing mechanisms. Moreover, enhancing community participation through co-management and livelihood diversification will increase social ownership and reduce dependency on extractive coastal activities.

Future success depends on embedding coral reef and seagrass conservation into national strategies for climate adaptation, biodiversity conservation, and sustainable coastal development. Establishing a Gulf-wide network of Marine Protected Areas (MPAs) interconnected through ecological corridors—will help maintain genetic exchange and habitat continuity. Expanding investment in research, restoration technology, and ecosystem accounting will further enable Thailand to transition from project-based restoration toward ecosystem-scale regeneration.

Ultimately, coral reefs and seagrass meadows must be recognized not only as habitats but as living natural infrastructures that protect coastlines, sustain fisheries, capture carbon, and support local economies. By integrating ecological science, policy innovation, and community stewardship, Thailand can ensure a resilient, carbon-neutral, and nature-positive Gulf of Thailand, securing these ecosystems for future generations.

4.2.3 Biodiversity Hotspots and Sensitive Areas

The Gulf of Thailand hosts an interconnected network of biodiversity hotspots that encompass coral reefs, seagrass meadows, mangrove forests, estuaries, and coastal wetlands. These ecosystems are ecologically sensitive and provide critical habitats for numerous threatened and endemic species. Key sites such as Koh Losin, Koh Kra, Koh Tao, Ban Don Bay, the Welu River Estuary, and Don Hoi Lot are recognized for their exceptional biodiversity, ecosystem productivity, and vital role in supporting fisheries, carbon storage, and coastal protection.

Collectively, these sites represent Thailand's most valuable coastal ecosystems, underpinning national and regional objectives in climate resilience, blue carbon management, and sustainable blue economy development. They are essential for nursery, spawning, and feeding grounds for commercially important marine species, while also sustaining the livelihoods of coastal communities.

Current Status by Ecosystem Type

Coral Reef Hotspots

Coral reefs across the Gulf of Thailand exhibit a pronounced spatial gradient in condition:

- Offshore reefs such as *Koh Kra*, *Koh Losin*, and *Koh Tao* maintain healthy to remarkably healthy status, with live coral cover between 59–70% and high structural complexity. Dominant genera include *Acropora, Porites, Montipora,* and *Pocillopora*. These reefs serve as biodiversity reservoirs and larval sources that sustain adjacent coastal systems.
- Mid-shelf and nearshore reefs, including *Koh Kood* and *Koh Mak*, show moderately healthy conditions (29–33% live coral cover) but exhibit signs of recovery under improved water quality and local conservation actions.
- Nearshore reefs near *Koh Si Chang* and *Koh Lan* are degraded, with coral cover below 40%, affected by sedimentation, eutrophication, and tourism-related pressures.
- Underwater pinnacles in Chumphon Province form unique mesophotic reef habitats supporting mixed coral assemblages (31% live cover) and diverse reef fish communities. Their vertical relief and hydrodynamics promote coral recruitment and larval dispersal between shallow and deeper reefs.

These coral reef hotspots are also critical refugia for large pelagic species and reef-associated fishes, maintaining high trophic diversity and ecological connectivity across the Gulf.

Seagrass meadows are concentrated primarily in Ban Don Bay (12.74 km²) and Chumphon Province (11.64 km²), serving as biodiversity nodes for dugongs, sea turtles, and juvenile fishes. The dominant species *Enhalus acoroides, Thalassia hemprichii, Halodule uninervis,* and *Halophila ovalis*reflect healthy, mixed meadows in shallow, sheltered bays. These meadows function as blue carbon sinks, estimated to store 35–60 tonnes C ha^{-1}, and play a vital role in nutrient cycling and sediment stabilization. However, fragmentation is increasing due to turbidity, nutrient enrichment, and coastal modification from aquaculture and infrastructure expansion.

Mangrove ecosystems and coastal wetlands especially at Welu River Estuary, Bandon Bay, Pak Phanang Bay, Samut Prakan, and Don Hoi Lotอ form Thailand’s coastal biodiversity foundation. These habitats support migratory birds, estuarine fishes, and crustaceans while acting as natural barriers against erosion and storm surges.

- Welu River Estuary provides extensive mangrove and tidal-flat habitats (~20,000 ha total area) and supports carbon storage, fisheries productivity, and community-based restoration programs.
- Bandon Bay contains ~17,000 ha of mangroves and 50,000 ha of tidal flats; it is a key blue-carbon landscape integrating seagrass, mangrove, and aquaculture systems.
- Pak Phanang Bay and Samut Prakan act as deltaic and urban wetland systems providing sediment retention, pollution filtration, and flood regulation.
- Don Hoi Lot (Ramsar Site) holds global significance as a wetland supporting endemic shellfish beds, migratory shorebirds, and intertidal biodiversity of the highest conservation value.

These areas are legally protected under frameworks such as National Reserved Forests, DMCR-managed Coastal Wetlands, National Parks, and Ramsar designations, forming a multi-layered protection network for coastal biodiversity.

Indicator Group Assessment

Ecological Indicators

Across hotspots, the live coral cover ranges from 29–70%, while seagrass coverage averages 25–30% in major bays. The biological integrity index classifies offshore reefs and mangroves as good, while nearshore reefs and estuaries rank moderate to poor due to cumulative pressures.
Key ecological indicators include:

- High coral species richness (>100 species site^{-1}) at Koh Losin and Koh Tao.
- Dense seagrass meadows supporting *Dugong dugon* populations in Chumphon and Surat Thani.
- Over 120 mangrove and wetland bird species at Don Hoi Lot and Bandon Bay.
- Estimated blue carbon stock > 5 million t CO_2 eq across the Gulf's mangrove–seagrass mosaic.

Threat Indicators

The major pressures identified are:

1. Sedimentation and turbidity from land-based runoff and port expansion.
2. Nutrient and chemical loading from aquaculture and agriculture.
3. Thermal stress and bleaching (notably in 2010, 2016, 2024).
4. Tourism and physical disturbance (anchoring, trampling, wastewater).
5. Microplastic contamination, with densities of 0.02–45 particles m^{-3} near urban coasts.
6. Overfishing and habitat modification reducing nursery and feeding grounds.

These stressors interact synergistically, leading to community shifts toward stress-tolerant coral genera (*Porites, Dipsastraea*) and lower seagrass diversity in degraded bays.

Socio-economic and Governance Indicators

Despite ecological pressures, community participation and restoration programs are increasing:

- DMCR-led restoration projects have rehabilitated > 1,000 ha of mangroves and 100 ha of seagrass meadows.
- Community-based monitoring networks in Chumphon and Bandon Bay track seagrass and coral conditions annually.
- Economic valuations show coastal ecosystem services worth US$20–32 million year^{-1} per major site, underscoring their contribution to Thailand's blue economy.
  However, governance fragmentation and enforcement challenges persist, especially in mixed-use coastal zones.

Spatial Trends and Biodiversity Linkages

Biodiversity hotspots form an interconnected ecological continuum:

- Eastern Gulf (Trat–Chanthaburi) hosts mixed coral–mangrove systems with high endemism.

- Central Gulf (Chonburi–Samut Prakan) experiences strong anthropogenic pressures but retains vital ecological corridors.
- Southern Gulf (Chumphon–Surat Thani–Nakhon Si Thammarat) contains the most extensive seagrass–mangrove complexes, supporting dugongs, dolphins, and migratory species.

The ecological linkages between coral reefs, seagrass meadows, and mangroves sustain nutrient flows and larval connectivity across trophic levels. Maintaining these linkages is crucial for biodiversity resilience, fisheries productivity, and blue-carbon potential.

Summary and Outlook

Biodiversity hotspots and sensitive areas in the Gulf of Thailand remain ecologically productive yet increasingly fragile. Offshore coral reefs and mangroves retain good ecological integrity, but nearshore and estuarine systems face cumulative threats from land-based activities and climate change.

To secure long-term resilience, Thailand should:

- Integrate ecosystem-based management across coral, seagrass, and mangrove systems.
- Institutionalize blue-carbon accounting and habitat restoration within national climate strategies.
- Strengthen community co-management and spatial planning to reduce localized pressures.
- Expand MPA and OECM networks to include seagrass and wetland habitats currently underrepresented in formal protection.

Through continued scientific monitoring, adaptive governance, and participatory restoration, these biodiversity hotspots can remain the living foundation for a nature-positive, climate-resilient Gulf of Thailand

4.2.4 Endemic, Endangered, and Threatened Species

Coral Reef Ecosystems

The coral reef ecosystems of the Gulf of Thailand harbor a high diversity of South China Sea endemic corals and numerous species listed under the IUCN Red List. Major reef systems include Koh Si Chang, Koh Lan, Koh Kood, Koh Mak, Koh Tao, Koh Kra, Koh Losin, and the underwater pinnacles of Chumphon Province. These areas represent biodiversity reservoirs and genetic refugia within the Western Indo-Pacific region.

- Endemic Species:
  Several coral species are regionally endemic to the South China Sea, including *Pectinia lactuca, Turbinaria patula, Acropora microclados, Merulina ampliata, Echinopora lamellosa, Pectinia paeonia,* and *Goniopora stokesi*. Their restricted distribution highlights the genetic uniqueness and biogeographical value of Thailand's reefs.
- Threatened Categories (IUCN):
  - Endangered (EN): *Pectinia lactuca*

- Vulnerable (VU): *Acropora humilis, A. muricata, A. millepora, A. hyacinthus, A. nasuta, Montipora digitata, M. foliosa, Pocillopora acuta,* and *Turbinaria patula*
- Near Threatened (NT): *Favia favus, Galaxea fascicularis, Porites lutea, Pavona cactus, Goniopora stokesi,* and *Heliopora coerulea* (Blue coral)

Offshore reefs such as Koh Kra and Koh Losin maintain high live coral cover (>60%) and retain significant endemic diversity, whereas nearshore reefs (Koh Si Chang, Koh Lan) are degraded, with live coral cover below 40%. These areas exhibit declines in *Acropora* and *Heliopora* populations due to sedimentation, eutrophication, and heat stress.

Biological Condition Indicators: The persistence of multiple endemic coral taxa reflects high genetic diversity and recovery potential in offshore systems. Conversely, the loss of branching coral species in nearshore areas indicates reduced resilience and the need for strengthened monitoring and restoration.

Seagrass, Mangrove, and Wetland Ecosystems

The seagrass meadows and mangrove–wetland complexes of the Gulf of Thailand provide critical habitats for several endemic and globally threatened species, functioning as nurseries, feeding grounds, and migratory stopovers. Key hotspots include Ban Don Bay, Pak Phanang Bay, Welu River Estuary, and Don Hoi Lot Ramsar Site.

- Endemic and Rare Plant Species:
  Endemic and rare mangrove species include *Bruguiera hainesii* (CR) and *Sonneratia griffithii* (CR), found at Welu Estuary and southern mangrove zones. *Heritiera fomes* (EN) occurs in localized patches in Ban Don Bay.
- Threatened Fauna:
  - Marine Mammals: *Dugong dugon* (VU) and *Orcaella brevirostris* (VU) are regularly sighted in Ban Don Bay and Chumphon, dependent on intact seagrass meadows.
  - Migratory Birds: *Calidris tenuirostris* (EN), *Egretta eulophotes* (VU), and *Rhyticeros subruficollis* (VU) occur in Don Hoi Lot and Pak Phanang wetlands, which form part of the East Asian–Australasian Flyway.
  - Fishes and Invertebrates: Threatened estuarine species such as *Pangasianodon hypophthalmus* (EN) and the endemic *Solen regularis* (bivalve) occur in tidal-flat and river-mouth zones.

Ecosystem Function Indicators: These habitats act as source and sink systems for larval dispersal, sustaining adjacent coral and coastal ecosystems. Don Hoi Lot serves as a critical benthic nursery area, maintaining connectivity and productivity across estuarine food webs. The presence of multiple IUCN-listed species underscores the global importance of Thailand's estuarine and seagrass ecosystems for biodiversity conservation.

Indicator Group Assessment

Offshore coral reefs in the Gulf of Thailand remain in good condition, supporting high endemic diversity, while vulnerable species show declines in nearshore zones.

Across all ecosystems, rising sea temperature, nutrient enrichment, and tourism-related physical disturbances pose major threats to coral and seagrass habitats. In response, Thailand has expanded its Ramsar sites, OECMs, and DMCR-led restoration programs that focus on rare and threatened species, including mangrove and seagrass rehabilitation efforts. Overall, the Gulf supports 7–10 endemic coral species and more than 25 IUCN-listed threatened species, with key populations of dugongs, Irrawaddy dolphins, and migratory birds sustained across interconnected coral, seagrass, and mangrove ecosystems.

The Gulf of Thailand remains a biodiversity hotspot of both regional and global significance, supporting a wide range of endemic, endangered, and threatened species across coral reef, seagrass, mangrove, and wetland ecosystems. These ecosystems together sustain critical ecological processes spawning, nursery, and migratory pathways that underpin fisheries productivity, blue carbon sequestration, and coastal resilience. Offshore coral reefs such as Koh Kra, Koh Losin, and Koh Tao maintain high live coral cover (60–70%) and host numerous endemic and vulnerable taxa including *Pectinia lactuca, Acropora humilis, Turbinaria patula,* and *Heliopora coerulea*. These reefs represent genetic reservoirs that support larval dispersal and species connectivity throughout the Gulf. In contrast, nearshore coral reefs (e.g., Koh Si Chang, Koh Lan) exhibit a marked decline in sensitive coral taxa due to sedimentation, nutrient loading, and recurrent bleaching events. In seagrass and mangrove ecosystems, populations of dugongs (*Dugong dugon*, VU), Irrawaddy dolphins (*Orcaella brevirostris*, VU), and migratory birds such as *Calidris tenuirostris* (EN) and *Egretta eulophotes* (VU) remain ecologically important indicators of habitat quality. These species depend heavily on intact Ban Don Bay, Chumphon, and Don Hoi Lot Ramsar Site, which provide feeding grounds, shelter, and breeding areas. Rare mangrove species such as *Bruguiera hainesii* (CR), *Sonneratia griffithii* (CR), and *Heritiera fomes* (EN) persist in fragmented stands, highlighting the need for continued habitat protection and assisted regeneration.

However, the cumulative pressures of coastal development, marine pollution, and climate-driven temperature anomalies continue to threaten the survival of these species. The degradation of coral-seagrass linkages and loss of mangrove buffer zones exacerbate ecological fragmentation, reducing the capacity of these habitats to sustain viable populations of threatened fauna. Maintaining and restoring these species requires an ecosystem-based management (EBM) approach, integrating conservation planning across marine and coastal landscapes. Priority actions include strengthening long-term monitoring of population trends, enhancing spatial protection through Marine Protected Areas (MPAs), Ramsar Sites, and Other Effective Area-Based Conservation Measures (OECMs), and improving coordination among agencies such as DMCR, DNP, and local governments.

Advancing scientific research on population genetics, reproductive biology, and larval connectivity will be essential for understanding recovery potential and identifying source populations for restoration. Moreover, integrating biodiversity protection into Thailand's Nationally Determined Contributions (NDCs) and Blue Economy Framework will elevate these species as indicators of ecosystem health and climate resilience. Ultimately, ensuring the persistence of Thailand's endemic and threatened marine species requires collective stewardship, adaptive governance, and sustainable financing. By combining science-based management, community participation, and blue carbon innovation, Thailand can safeguard its unique marine heritage and achieve a resilient, carbon-neutral, and nature-positive Gulf of Thailand for generations to come.

4.3 Discussion and conclusions

4.3.1 Priority Transboundary Biodiversity Issues

The assessment of coastal and marine ecosystems across the Gulf of Thailand reveals that biodiversity loss, ecosystem degradation, and transboundary pressures are tightly interconnected. These challenges transcend administrative borders and require regional cooperation under frameworks such as the Strategic Action Programme (SAP) for the South China Sea and ASEAN's Post-2020 Biodiversity Framework.

Key transboundary biodiversity issues include:

1. Habitat fragmentation and loss of ecological connectivity: Coral reefs, seagrass meadows, and mangrove wetlands that form continuous ecological corridors are increasingly disrupted by sedimentation, dredging, reclamation, and urban expansion. These pressures impede larval dispersal and migratory pathways, particularly across border-linked coastal provinces and shared fishing grounds.
2. Declining populations of shared and migratory species: Endangered taxa such as *Dugong dugon*, *Orcaella brevirostris*, *Calidris tenuirostris*, and *Egretta eulophotes* migrate across Thailand, Cambodia, and Vietnam. Their survival depends on intact transboundary habitats and coordinated protection of seagrass and mangrove ecosystems.
3. Cumulative impacts of climate change and pollution Rising sea-surface temperatures, acidification, and nutrient enrichment from upstream catchments exacerbate coral bleaching, eutrophication, and hypoxia. These pressures are compounded by microplastic contamination and heavy-metal inputs, which are transboundary by nature.
4. Uneven management capacities: While Thailand has strengthened protection through MPAs, Ramsar Sites, and OECMs, cross-border governance and data-sharing remain fragmented. Limited regional integration constrains effective monitoring, enforcement, and restoration at the ecosystem scale.

The report emphasizes that priority transboundary biodiversity issues must be addressed through joint management and knowledge sharing among Gulf-rim countries. Thailand's approach linking blue carbon conservation, community-based restoration, and ecosystem-based management (EBM) provides a replicable model for cooperative action under the South China Sea SAP.

To sustain progress, four strategic directions are proposed:

- Strengthen regional ecological networks by linking coral, seagrass, and mangrove corridors through shared spatial data and habitat connectivity mapping.
- Harmonize monitoring protocols and biodiversity indicators under ASEAN and COBSEA frameworks to enable joint reporting on ecosystem condition and species status.

- Institutionalize transboundary governance through bilateral agreements on migratory species management, pollution control, and sustainable fisheries.
- Mobilize blue-economy financing for habitat restoration, blue carbon projects, and community participation across borders.

In conclusion, conserving biodiversity in the Gulf of Thailand requires moving from isolated national actions to regionally coordinated, ecosystem-based management. Strengthened transboundary collaboration will ensure that critical habitats coral reefs, seagrass meadows, and mangrove wetlands continue to provide ecological, economic, and climate-resilience benefits for all countries sharing the South China Sea.

4.3.2 Risk Assessment and Valuation of economic losses

The valuation and risk assessment of Thailand's coastal and estuarine ecosystems highlight both their immense economic importance and vulnerability to degradation. Across key study areas Welu River Estuary, Bandon Bay, Pak Phanang Bay, Samut Prakan Province, and Don Hoi Lot rapid socio-economic expansion has reshaped environmental conditions, increasing exposure to ecological and financial risks. The primary drivers of risk include population growth, aquaculture intensification, industrial and tourism development, and land-use conversion. These pressures have accelerated habitat loss, sedimentation, nutrient loading, and water-quality decline, undermining the resilience of mangrove and seagrass ecosystems that underpin local fisheries and coastal protection. The loss of these natural buffers exposes coastal communities to greater economic losses from erosion, flooding, and declining fishery productivity.

Despite these threats, the ecosystems continue to generate substantial economic benefits. The estimated annual ecosystem service value ranges between US$17–32 million per site, combining both direct use values fisheries, aquaculture, timber, and mangrove products and indirect services such as coastal protection, carbon sequestration, and nutrient cycling. For example, Bandon Bay contributes up to US$32 million per year, while Welu River Estuary provides US$18–23 million annually, supported by blue-carbon stocks valued over US$130–185 million. These findings confirm that coastal ecosystems are key natural assets within Thailand's blue-economy and climate-resilience strategies.

However, risk exposure remains high where governance and enforcement are weak. In Don Hoi Lot and Samut Prakan, unregulated harvesting, pollution, and industrial expansion have diminished ecosystem capacity, resulting in measurable declines in ecosystem service value. Economic risk thus extends beyond resource loss to include reduced livelihood security, higher restoration costs, and forgone carbon-credit potential.

The report concludes that mitigating future economic losses requires:

1. Integration of ecosystem valuation into policy and planning—ensuring that natural capital is recognized in cost-benefit analyses and climate-finance mechanisms.
2. Strengthened coastal zoning and enforcement to limit unsustainable land conversion and aquaculture expansion.

3. Investment in ecosystem restoration (mangrove rehabilitation, blue-carbon projects) to offset cumulative losses and generate long-term returns.
4. Community-based risk management, linking local livelihood diversification with conservation incentives.

In summary, Thailand's coastal ecosystems represent high-value yet high-risk natural infrastructure. Embedding economic valuation and risk assessment into national coastal governance is essential to reduce vulnerability, maintain ecosystem services, and ensure sustainable, climate-resilient development across the Gulf of Thailand.

4.3.3 Current Management and Institutions

The management and institutional framework of Thailand's coastal and marine ecosystems demonstrates a long-standing commitment to sustainable resource use and biodiversity protection. However, institutional fragmentation and limited enforcement capacity remain significant challenges. Five major management zones Welu River Estuary Bandon Bay, Pak Phanang Bay, Samut Prakan Province, and Don Hoi Lot represent key areas under state ownership and collaborative management, integrating ecosystem restoration, blue carbon initiatives, and participatory coastal governance.

The Department of Marine and Coastal Resources (DMCR) serves as the principal coordinating agency for mangrove, coral reef, and seagrass conservation, working in partnership with the Department of National Parks, Wildlife and Plant Conservation (DNP), Department of Fisheries (DOF), Royal Irrigation Department (RID), and provincial and local administrations. These agencies collectively manage coastal zoning, pollution control, aquaculture development, and habitat restoration, with growing engagement from universities and NGOs in biodiversity monitoring, citizen science, and blue carbon assessment. Co-management arrangements have emerged as key governance mechanisms in Welu Estuary, Bandon Bay, and Pak Phanang Bay, where local communities actively participate in mangrove rehabilitation, water-quality improvement, and sustainable aquaculture. Samut Prakan Province demonstrates an urban–industrial wetland restoration model, integrating CSR-led mangrove planting, wastewater treatment, and public awareness programs. Don Hoi Lot (Ramsar Site No.1099) serves as Thailand's leading example of community-based ecotourism and participatory wetland management, combining biodiversity protection with sustainable livelihood development.

Coral Reef and Seagrass Management

Beyond mangrove and wetland systems, Thailand's coral reef and seagrass ecosystems are managed under joint DMCR–DNP frameworks.

- Coral reefs across sites such as Koh Si Chang, Koh Tao, Koh Mak, Koh Kood, Koh Kra, and Koh Losin are managed through a combination of Marine Protected Areas (MPAs), OECMs, and local conservation initiatives. Offshore reefs (e.g., Koh Kra and Koh Losin) are under direct DMCR management, maintaining high ecological integrity due to restricted access, while nearshore reefs (e.g., Koh Si Chang, Koh Lan) face challenges from tourism, sedimentation, and eutrophication, requiring stronger enforcement and local co-management.

- Underwater pinnacles in Chumphon Province are increasingly recognized for their connectivity and larval dispersal function, and are being considered for formal protection as an OECM site.
- Seagrass, notably in Bandon Bay and Chumphon, are managed under DMCR's blue carbon and biodiversity programs, linking habitat conservation with carbon sequestration and sustainable fisheries. Restoration and monitoring activities are conducted in collaboration with local fishery groups and academic institutions, contributing to Thailand's Nationally Determined Contributions (NDC) and Blue Economy Strategy.

Integration and Ongoing Challenges

While institutional frameworks have expanded Thailand's conservation network, overlapping mandates, inconsistent data-sharing, and limited coordination between national and provincial levels continue to undermine management efficiency. Enforcement of marine zoning and fishing regulations remains inconsistent, particularly in nearshore coral and seagrass areas where tourism and aquaculture activities are expanding rapidly. There is also a need to align restoration and monitoring programs under a unified spatial planning and reporting system.

Toward Integrated and Adaptive Governance

Progress is evident in the adoption of Integrated Coastal Management (ICM) and the incorporation of ecosystem-based approaches into the National Marine and Coastal Resources Management Plan (2023–2027). New initiatives—such as blue carbon accounting, sustainable tourism guidelines, and community-based restoration programs—are being implemented in Don Hoi Lot, Bandon Bay, and Chumphon, showcasing Thailand's shift toward adaptive, science-based, and participatory governance.

In conclusion, Thailand's institutional landscape for coastal and marine ecosystem management has evolved toward inclusivity, decentralization, and science-driven planning. To ensure long-term ecological and socio-economic resilience, it is essential to (1) clarify institutional mandates; (2) strengthen inter-agency coordination and local capacity; (3) institutionalize co-management across all ecosystem types; and (4) secure sustainable financing for restoration, blue carbon, and biodiversity conservation. These actions will reinforce Thailand's leadership in marine governance and contribute directly to achieving national goals for nature-positive and climate-resilient development.

Name	**Estbld year**	**Updtd year**	**Total area (ha)**	**MG area (ha)**	**WL area (ha)**	**CR area (ha)**	**SG area (ha)**
Welu River Estuary	-	2024	10,400	7,206	–	–	–
Bandon Bay	–	2024	49,459	25,570	–	–	–
Pak Panang Bay	–	2024	13,597	9,000	111	–	–
Samut Prakan Province	–	2024	100,412	3,374	–	–	–
Don Hoi Lot	-	2024	87,500	2,919	24,090	–	–

Name	Estbl d year	Updt d year	Total area (ha)	MG area (ha)	WL area (ha)	CR area (ha)	SG area (ha)
Koh Si Chang	-	2024	--	-	-	35	-
Koh Lan	-	2024		-	-	118	-
Koh Tao	-	2024	-	-	-	1,318	-
Koh Mak	-	2024	-	-	-	504	-
Koh Kood	-	2024	-	-	-	66	-
Koh Kra	-	2024	-	-	-	13	-
Koh Losin	-	2024	-	-	-	35	-
Underwater pinnacle Chumphon Province	-	2024	-	-	-	-	-
Ban Don Bay	-	2024	-	-	-	-	1,274
Chumphon	-	2024	-	-	-	-	1,164

4.3.4 Gaps and Priority Challenges

The assessment reveals that while Thailand has made significant progress in coastal ecosystem management and biodiversity conservation, persistent institutional, technical, and financial gaps continue to hinder effective implementation. These gaps undermine ecosystem resilience, equitable resource use, and the transition toward sustainable, climate-resilient coastal governance.

1. Institutional and Policy Gaps

Fragmented institutional mandates and limited coordination among national and provincial agencies (e.g., DMCR, DNP, RID, and local authorities) have led to overlapping responsibilities and inconsistent enforcement. Despite the presence of national frameworks—such as the *National Marine and Coastal Resources Management Plan (2023–2027)* and the *Thailand Blue Economy Strategy*—integration across ministries and between land- and sea-based sectors remains weak. Policy continuity and long-term financing mechanisms for ecosystem restoration are often dependent on short-term projects, constraining sustained management outcomes.

2. Scientific and Technical Gaps

Monitoring and data systems for coral reefs, seagrass, mangroves, and coastal wetlands are still uneven and site-specific, limiting the ability to assess cumulative impacts or track long-term ecological change. Critical information gaps include genetic diversity, larval connectivity, blue-carbon fluxes, and socio-economic valuation. The absence of standardized indicators and data-sharing protocols impedes cross-sectoral planning and regional collaboration, particularly for transboundary ecosystems within the Gulf of Thailand.

3. Socio-Economic and Governance Challenges

Coastal resource use remains heavily influenced by market-driven pressures, including aquaculture expansion, industrial development, and unregulated tourism. These drivers exacerbate habitat degradation and social inequality in resource access. Community-based management initiatives have proven effective in pilot sites but often lack formal institutional support, legal recognition, and access to financing. Limited incentives for sustainable practices reduce participation in conservation and blue-carbon initiatives.

4. Climate and Environmental Pressures

Rising sea-surface temperatures, erosion, saltwater intrusion, and changing rainfall patterns have amplified ecosystem vulnerability, particularly in deltaic and estuarine regions such as Bandon Bay and Pak Phanang Bay. The lack of integrated catchment-to-coast planning and weak adaptation frameworks leave coastal communities increasingly exposed to climate-induced risks and economic losses.

5. Priority Actions

To close these gaps, the report recommends:

- Establishing a unified national database for coastal and marine biodiversity monitoring.
- Institutionalizing ecosystem-based and blue-carbon accounting into national planning and climate-finance systems.
- Strengthening co-management and community empowerment with sustained technical and financial support.
- Enhancing regional coordination under the South China Sea SAP and ASEAN Biodiversity Framework for transboundary habitat protection.

Bridging these gaps requires transforming Thailand's coastal governance from project-based interventions to systemic, science-driven, and inclusive management. Prioritizing long-term investment in data, institutions, and community partnerships will ensure that the Gulf of Thailand's ecosystems continue to provide vital ecological, economic, and climate-resilience benefits for the nation and the region.

4.3.5 Recommended priority actions including regional cooperation

The findings of the Transboundary Diagnostic Analysis (TDA) for Thailand highlight that the long-term sustainability of the Gulf of Thailand's ecosystems depends on collective action addressing biodiversity loss, ecosystem degradation, and climate change impacts. To secure the ecological and socio-economic value of these ecosystems, the report identifies a series of priority actions and regional cooperation mechanisms that strengthen science-based management, policy integration, and stakeholder participation.

1. Strengthening Ecosystem-Based Management and Restoration

Thailand should accelerate the implementation of ecosystem-based management (EBM) across coral reef, seagrass, mangrove, and wetland ecosystems. This includes scaling up restoration projects, establishing ecological corridors that link critical habitats, and integrating blue carbon management into climate strategies. Ongoing initiatives under the Department of Marine and Coastal Resources (DMCR), such as mangrove rehabilitation, coral and seagrass restoration, and OECM site designation, provide models for replication across the region.

2. Enhancing Policy Integration and Institutional Coordination

To address fragmented governance, the report calls for the harmonization of coastal management policies among key agencies (DMCR, DNP, RID, Department of Fisheries, and local governments). Developing a unified national marine spatial database and strengthening coordination mechanisms between the National Committee on Marine and Coastal Resources Management and provincial authorities are essential to ensure consistent planning, enforcement, and monitoring.

3. Expanding Regional Cooperation under the South China Sea and ASEAN Frameworks

Given the shared ecological and economic importance of the Gulf of Thailand, regional collaboration is critical. Thailand should continue active engagement with neighboring countries Cambodia, Vietnam, and Malaysia through the Strategic Action Programme (SAP) for the South China Sea, COBSEA, and the ASEAN Centre for Biodiversity (ACB). Joint research on transboundary species migration, marine pollution control, and blue carbon accounting should be prioritized to harmonize monitoring and support regional policy coherence.

4. Promoting Sustainable Blue Economy and Financing Mechanisms

Economic growth must align with ecosystem resilience. The report recommends developing coastal financing mechanisms, including blue bonds, payment for ecosystem services (PES), and carbon-credit markets for mangrove and seagrass restoration. Strengthening community-based enterprises in ecotourism and sustainable aquaculture can generate inclusive benefits while reducing resource pressure.

5. Building Capacity and Knowledge Sharing

Regional and national institutions should enhance capacity-building through technical training, knowledge exchange, and data-sharing platforms. The establishment of a Regional Marine Biodiversity Data Hub under ASEAN and COBSEA would facilitate access to standardized datasets, improving joint decision-making and progress tracking toward Sustainable Development Goals (SDGs 13, 14, and 15).

Effective conservation and management of the Gulf of Thailand’s ecosystems depend on Thailand’s ability to transition from localized projects to integrated, regionally coordinated action. By coupling national leadership with regional cooperation, Thailand can strengthen biodiversity protection, enhance blue-carbon potential, and secure sustainable livelihoods, positioning the Gulf as a model for transboundary marine governance and climate-resilient development within the South China Sea region.

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V. Fisheries

Thailand is located between two oceans: the Gulf of Thailand, which is part of the Pacific Ocean, and the Strait of Malacca and the Andaman Sea, which are parts of the Indian Ocean. Fishery in Thailand is divided into two sectors: capture fishery and culture fishery. In terms of production, capture fisheries contribute approximately 60% of the fisheries production, while the remaining 40% comes from culture fisheries. The capture fisheries occur both in inland and marine areas. Catch from marine capture fisheries contribute 93% of the total capture fisheries production, while catch from inland capture fisheries contribute only 7%. Marine fisheries in Thailand are divided into two sectors – artisanal and commercial fisheries. Artisanal fisheries are characterized by vessels that are less than 10 gross tons, while commercial fisheries include those from 10 gross tons and above.

Marine fisheries play an important role in Thailand's economy. In 2024, the total catch from marine fisheries was 1.43 million tonnes (0.96 million tonnes in the Gulf of Thailand and 0.47 million tons in the Andaman Sea), valued at 2,267 million USD (1,607 million USD in the Gulf of Thailand and 660 million USD in the Andaman Sea). The per capita consumption of aquatic animals in Thailand in 2024 was 34.76 kg/person/year. In addition, Thailand exported 1.76 million tonnes of fisheries products to several countries around the world, worth 7,387 million USD, with some of the raw materials imported for processing and export. The main importing countries of fisheries products from Thailand include the USA, Japan and China. The marine fishing industry also generates employment and income for related activities such as fishing ports, shipyards, ice factories, seafood processing plants, and fishing gear factories. Thailand's marine fisheries also generate a large number of jobs. There are approximately 190,000 workers on artisanal and commercial fishing vessels, 215,000 workers at 1,608 fishing ports, and 338 fish processing plants.

The Gulf of Thailand is a highly productive area, nourished by several rivers that carry various nutrients into the gulf. These nutrients are used by phytoplankton for photosynthesis, making phytoplankton the primary producers and the starting point of the food chain. The Gulf of Thailand also features diverse ecosystems, such as mangrove forests, coral reefs, and seagrass beds, which serve as critical habitats for spawning and nursing areas for aquatic species. As a result, the Gulf of Thailand has a wide variety of fisheries resources and serves as an important fishing ground in Thai waters. Notably, marine fisheries production from the Gulf of Thailand accounts for 70% of the total catch.

Fisheries management system in Thailand is based on the Royal Ordinance on Fisheries B.E. 2558 (2015). The management system has been shifted from an open access fishery to a limited access fishery. A key principle of the current fisheries law is that fisheries resource management must be based on a reference point. Currently, Maximum Sustainable Yield (MSY) is used as the reference point. MSY is calculated annually, and the Total Allowable Catch (TAC) is determined based on the MSY. Several management measures have been issued under the Royal Ordinance. This chapter presents some background information on marine fisheries in the Gulf of Thailand, including fisheries production, fishing vessel, and fishing gear, fisheries indicators, fish stock assessment, and fisheries management measures.

5.1. Key finding

Fisheries development in Thai waters had resulted in overfishing and a decrease in the abundance of aquatic resources, which could be seen in the decrease in the catch per unit effort (CPUE) of research vessels, which is used as an indicator of resource abundance. In 1971, the total catch in the Gulf of Thailand was 481,270 metric tonnes and increased to a maximum of 1,590,104 metric tonnes in 1989. It then remained relatively stable, ranging from 903,935 to 1,040,058 metric tonnes between 2008 and 2023. Meanwhile, the CPUE in 1961, when the trawl fishery was first introduced to Thailand, was about 300 kg/hr. The CPUE then rapidly decreased during the first decade of trawl fishery development to 87.07 kg/hr in 1971 and continued decreasing to around 20 kg/hr during the 2010s.

Following the enactment of the Royal Ordinance on Fisheries B.E. 2558 (2015), overfishing has ended and resources have recovered to levels where biomass can produce MSY. The number of fishing vessels were frozen to reduce fishing capacity, resulting in a continuous decrease in the number of commercial fishing vessels in the Gulf of Thailand from 9,122 vessels in 2016 to 7,053 vessels in 2024. As the fisheries law supports artisanal fishing, the number of registered vessels has increased from 27,200 vessels in 2016 to 45,600 vessels in 2025. In addition, several management measures under the new fisheries law have been imposed such as fishing day limitation for commercial fishing vessels using high efficiency gears, seasonal area closures, and fishing gear control (e.g. mesh size limitation, destructive fishing gear banned, and fishing gear efficiency control). By implementing these measures, fishing effort has been controlled not exceeding the optimum level (F_{MSY}) and biomass of all species groups, namely demersal species, pelagic fish, and anchovy is higher than B_{MSY}. Marine Trophic Index also reached its maximum during the last 20 years, indicating that the ecosystem is recovering.

However, marine fisheries in the Gulf of Thailand still face problems with small-sized fish caught from trawlers, which has slowed the recovery of demersal species. Furthermore, fisheries management in the Gulf of Thailand requires cooperation among countries in the Gulf of Thailand and the South China Sea region to research transboundary species and to cooperate in joint fisheries resource management.

5.2. Fisheries and aquaculture production

Thailand has systematically collected marine fisheries statistics since 1971. In that year, the total catch in the Gulf of Thailand was 481,270 metric tonnes. After that, the catch increased rapidly, reaching a maximum of 1,590,104 metric tonnes in 1989. It then showed a deceasing trend to the lowest of 906,781 metric tonnes in 2007. Between 2008 and 2023, the catch remained relatively stable, ranging from 903,935 to 1,040,058 metric tonnes. The recent catch in 2023 was 1,022,529 metric tonnes (Figure 1 and Annex Table 1).

In terms of catch composition, the total catch was dominated by demersal and pelagic fishes. The development of trawl fisheries contributed to higher demersal fish catches, increasing from 353,684 metric tonnes in 1971 to a maximum of 893,374 metric tonnes in 1987. After that, the demersal catch continuously decreased due to overfishing for a couple of decades. Over the last 20 years, the demersal catch ranged from 367,707 to 508,872 metric tonnes, with an average of 424,462 metric tonnes. On the other hand, during the early 1970s, pelagic fish catches were still very low compared to demersal fish catches. However, in the mid-1970s, purse seine fisheries were developed using light luring and fish aggregating devices, which increased the catch of pelagic fish to near demersal fish catches. During the last 20 years, the pelagic catches have been quite stable, ranging from 334,330 to 426,643 metric tonnes, with an average of 367,567 metric tonnes (Figure 1 and Appendix Table 1).

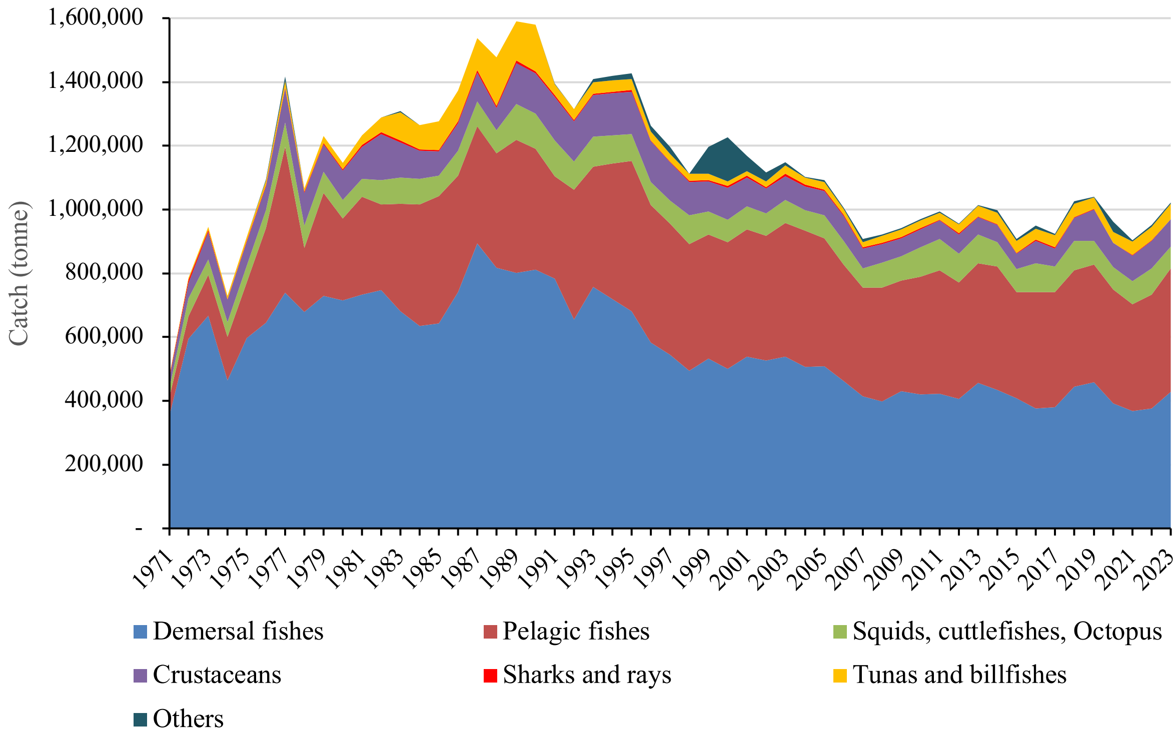


Figure 1 Annual catch and catch composition from marine fisheries in the Gulf of Thailand between 1971 and 2023

Inland capture fisheries production in the coastal provinces along the Gulf of Thailand was 11,164.2 metric tonnes in 2009 and increased to 14,810.2 metric tonnes in 2012. After that, the production continuously decreased to 8,362.69 metric tonnes in 2023. The inland fisheries catch mainly consisted of freshwater fishes, approximately 95% of the total catch, and a few percentages of freshwater crustaceans (Appendix Table 2).

For aquaculture, the main cultured species are brackish water and marine species, such as marine shrimps (e.g. giant tiger prawn, whiteleg shrimp, and banana prawn), brackish water fishes (e.g. barramundi, groupers, and milkfish), shellfishes (e.g. blood cockle, green mussel, and oyster), and crabs. In addition, there is some freshwater aquaculture in the coastal provinces. The major cultured species include Nile tilapia, catfish, common silver barb and giant freshwater prawn. The annual production between 2016 and 2023 ranged from 440,829.50 to 513,074.18 metric tonnes, with an average of 481,088.66 metric tonnes. The production in 2023 was slightly higher than the average, at 496,446.64 metric tonnes. In recent years, Chachoengsao Province has produced the highest aquaculture production among the coastal provinces along the Gulf of Thailand, followed by Surat Thani Province (Appendix Table 3).

5.3. Number of fishing vessels and fishing gears

Fishing vessels in Thailand are categorized into two groups, namely artisanal and commercial fishing vessels. Artisanal fishing vessels are characterized by the vessel size of less than 10 gross tonnage (GT), while commercial fishing vessels are those of 10 GT and above. Commercial vessels are required to have a fishing license. Fishing gears in Thailand are also categorized into two groups, namely high efficiency gear (HEG) and low efficiency gear (LEG). High efficiency gears refer to less selective gear, such as trawls, purse seines, and anchovy falling net, while low efficiency fishing gears refer to more selective gears, such as traps, gillnets, clam dredges.

The number of vessels having a commercial fishing license in the coastal provinces along the Gulf of Thailand was 9,122 vessels in 2016. Since then, the number of fishing vessels has gradually decreased to 7,053 vessels in 2024 (Table 1). Several measures have been implemented to control the number of fishing vessels. The issuance of fishing license is based on biological reference point, as described in the Royal Ordinance on Fisheries B.E. 2558 (2015). As Thailand has been facing an overcapacity problem, i.e., an excessive number of fishing vessels, no new fishing vessel is allowed to be registered as a commercial fishing vessel. Fishing vessels may deteriorate over time, or fishers may withdraw from the fishing business on their own.

Table 1 Number of fishing vessels having commercial fishing license in the coastal provinces along the Gulf of Thailand between 2016 – 2024

Year	Number of fishing vessels having commercial fishing license
2016	9,122
2017	8,906
2018	8,692
2019	8,598
2020	8,449
2021	8,190
2022	7,703
2023	7,603
2024	7,053

In addition, the government has been implementing a vessel buyback program. Since 2016, more than 1,000 vessels have been bought back, and the vessels must be either destroyed or have their permit changed to other propose before receiving compensation from the government, to ensure that fishing vessels are permanently removed from the fisheries system. The government has also been implementing a fishing license combination program. A fishing day scheme has been introduced to address the overfishing problem and control the level of fishing effort by limiting the number of fishing days per year for each type of fishing gear. For instance, the number of fishing days for trawlers in the Gulf of Thailand was 220 days/year in 2016-2017, increased to 240 days/year in 2018-2023, and reached 245 days/year in 2024-2025 (Table 2). To allow the fishers to have more fishing days, vessel owners can transfer fishing days from one vessel to other vessels, on the condition that the original vessel is removed from the fisheries system. These are some of the management measures implemented to effectively reduce the number of fishing vessels.

In 2016-2017, commercial fishing vessels were allowed to apply for only one type of HEG or one type of LEG. The unit of fishing gear was only 9,096 and 8,878, respectively. The most commonly used fishing gear was trawl, i.e., otter board trawl, beam trawl, and pair trawl. with 3,087 and 3,043 licensed vessels, followed by falling net, i.e., anchovy falling net and squid falling net, with 1,767 and 1,747 licensed vessels, respectively (Appendix Table 4).

However, in 2018, vessel owners were allowed to apply for one type of HEG and one type of LEG for the same vessel. Handline could also be applied in addition to either HEG or LEG. In case where they applied for only LEG, they could apply for up to three types of LEG, plus handline. Thus, the unit of fishing gear increased to 16,509 in 2018. Handline became the most commonly used fishing gear, with 7,332 units, because almost all vessels applied for handline to be equipped on board and used time to time by crews. However, when considering the main fishing gear, trawls were still the most commonly used, with a slightly lower number of 2,975 units. After that, the number of fishing gear units showed a decreasing trend following the reduction in the number of fishing vessels, reaching 14,196 units in 2024 (Appendix Table 4). Although, a fishing vessel may apply for multiple fishing gears, only one type of fishing gear must be operated at a time.

Table 2 Number of fishing days allocated to each type of fishing gear operated in the Gulf of Thailand between 2016 and 2025

Group of fishing gear	**Type of fishing gear**	**Number of fishing days (day/year)**		
		2016 - 2017	**2018 - 2023**	**2024 -2025**
High efficiency fishing gear	Otter board trawl, beam trawl, pair trawl	220	240	245
	Purse seine	220	240	255
	Anchovy falling net, anchovy lift net, anchovy purse seine	235	255	270
	Light luring vessel	Not defined		
Low efficiency fishing gear	Squid falling net, traps, krill push net, gillnets, clam dredges, pomfret lift net, longline, handline, red frog crab lift net	Not defined		

In 2024, Pattani province had the highest number of fishing gear units, totaling 1,822 because it had the largest number of purse seiners, with 146 licensed vessels. These purse seiners are often operated with light luring vessels, which are also required to obtain a fishing license. These fishing vessels commonly have handlines equipped on board. Chumphon Province ranked second, with 1,637 fishing gear units, for the same reason as Pattani - it has a large number of purse seiners. It was followed by Nakhon Si Thammarat province, where the situation differs, as the province has the highest number of trawlers in the Gulf of Thailand, totaling 572 vessels (Appendix Table 5).

5.4. Fisheries and ecosystem indicators

5.4.1 Catch per unit effort

The Department of Fisheries (DOF) has been conducting annual fisheries resource surveys since 1961 using research vessels equipped with otter board trawl with cod-end mesh size of 2.5 cm. In 1961, when trawl was first introduced to Thailand, the catch per unit effort (CPUE) in the Gulf of Thailand was 297.80 kg/hr. Thereafter, the CPUE gradually decreased to 127.90, 63.31, and 25.82 kg/hr in 1970, 1980, and 1990, respectively. It further declined to its lowest of 14.69 kg/hr in 2013.

In 2016, the DOF began using otter board trawl with cod-end mesh size of 4.0 cm for the surveys, in accordance with the cod-end mesh size requirement prescribed under the Royal Ordinance on Fisheries B.E. 2558 (2015). The survey in 2016 recorded a CPUE of 12.61 kg/hr. Then, the CPUE showed an increasing trend to 21.52 kg/hr in 2023. However, in 2024, the CPUE decreased again to 16.62 kg/hr (Figure 2 and Appendix Table 6).

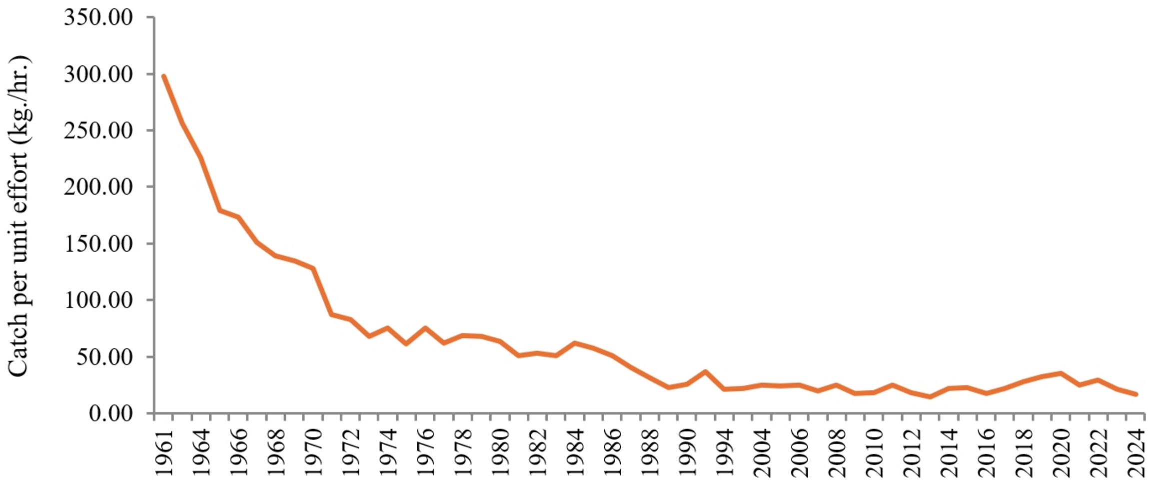


Figure 2 Catch per unit effort of DOF research vessels using otter board trawl in the Gulf of Thailand between 1961 and 2024

Remark: The cod-end mesh size used between 1961 and 2015 was 2.5 cm, while the cod-end mesh size of 4.0 cm has been used since 2016.

5.4.2 Fishing effort

For stock assessment purpose, fisheries resources in Thai waters are divided into three species groups, namely demersal species, pelagic fish, and anchovy. The demersal species include demersal fishes, squids and cuttlefishes, shrimps, crabs, clams, and krill, while the pelagic fish are all midwater and pelagic fishes, including mackerels, scads, sardines, barracudas, and neritic tunas. The anchovy group includes all species of *Encrasicholina* spp. and *Stolepholus* spp. The Maximum Sustainable Yield (MSY) assessment for the three groups of species is conducted every year using the Fox surplus production model (Appendix A) (Fox, 1970).

The fishing effort of demersal species, pelagic fish, and anchovy in 2015, just before the implementation of limited access fishery prescribed under the Royal Ordinance on Fisheries B.E. 2558 (2015), was above the fishing effort at MSY level

(E_{MSY}) at 148.76%, 136.95%, and 100.88% of the E_{MSY}, respectively, indicating overfishing for all groups of species. The year 2016 was the first year that the fishing license issuance was based on the biological reference point. In 2016, the fishing effort significantly declined. For demersal group, the fishing effort in 2016 and 2017 was 79.93% and 97.77% of the E_{MSY}, respectively. After that, until 2024, the fishing effort ranged from 62.30 to 82.57% of the E_{MSY}. For the pelagic fish group, the fishing effort in 2016 was still high at 115.19% of the E_{MSY}, but it was subsequently controlled to remain well below the E_{MSY} level, ranging from 41.42 – 68.86% of E_{MSY} between 2021 - 2024. For anchovy group, the fishing effort continuously declined and has remained around 20% of the E_{MSY} during the past five years (Table 3).

Table 3 Fishing effort at MSY (E_{MSY}) and standard fishing effort of demersal species, pelagic fish, and anchovy group in the Gulf of Thailand between 2015 and 2024

Year	Demersal species			Pelagic fish			Anchovy		
	Fishing effort at MSY (hour)	Standard fishing effort (hour)	% fishing effort	Fishing effort at MSY (day)	Standard fishing effort (day)	% fishing effort	Fishing effort at MSY (day)	Standard fishing effort (day)	% fishing effort
2015	24,331,498	36,196,522	148.76	130,493	178,709	136.95	114,588	115,600	100.88
2016	26,326,863	21,042,318	79.93	152,512	175,677	115.19	155,923	75,992	48.74
2017	22,796,139	22,287,587	97.77	135,882	111,999	82.42	171,378	55,518	32.40
2018	23,268,351	19,213,636	82.57	136,386	114,204	83.74	172,880	60,722	35.12
2019	22,606,170	17,342,281	76.71	133,991	113,705	84.86	172,480	52,476	30.42
2020	23,104,173	15,507,765	67.12	142,723	100,837	70.65	158,813	32,522	20.48
2021	23,438,995	19,305,368	82.36	145,134	78,934	54.39	126,358	23,381	18.50
2022	23,954,077	14,923,835	62.30	207,303	85,873	41.42	133,934	24,998	18.66
2023	24,180,496	16,293,292	67.38	210,272	122,184	58.11	127,569	30,134	23.62
2024	24,905,641	16,057,399	64.47	180,849	124,535	68.86	127,917	28,857	22.56

5.4.3 Stock biomass

As fisheries resources in Thai waters are divided into three species groups - demersal species, pelagic fish, and anchovy - biomass was calculated for each group using JABBA (Just Another Bayesian Biomass Assessment) (Winker *et al.*, 2018). The input data includes time-series catch and catch per unit effort. The model also requires several parameters, namely, K (carrying capacity), r (intrinsic rate of population increase), and B (initial biomass).

The assessment results from JABBA present two dimensions of fisheries resource status –biomass (B) and fishing mortality (F). The biomass of all species groups in the Gulf of Thailand in 2023 was higher than the biomass that can produce the Maximum Sustainable Yield (B_{MSY}). The B/B_{MSY} of demersal species, pelagic fish, and anchovy was 1.007, 1.294, and 2.191, respectively (Table 4 and Figure 3). The biomass assessment results indicated a recovery of fisheries resources in the Gulf of Thailand. In 2023, fisheries resources across all species groups were abundant and exceeded the level required to achieve MSY. However, demersal species have a low natural recovery rate and may take longer to recover than other groups. In addition, fishing mortality of all groups in 2023 was well below the fishing mortality that can produce MSY (F_{MSY}), particularly anchovy group which the F/F_{MSY} was about 0.2 indicating that fishing effort can be increased (Figure 3).

In addition to the species group assessment, the DOF has also conducted single species assessments. In 2023, 17 economically important species were selected to represent species groups, including 12 demersal species, four pelagic species, and one anchovy species. A length-based model was used to estimate the biomass. The results showed that the biomass of 11 species in 2023 was higher than B_{MSY}, one species was at B_{MSY}, and five species were lower than B_{MSY}. The latter group consisted of three species of demersal fauna and two species of pelagic fish (Appendix Table 7).

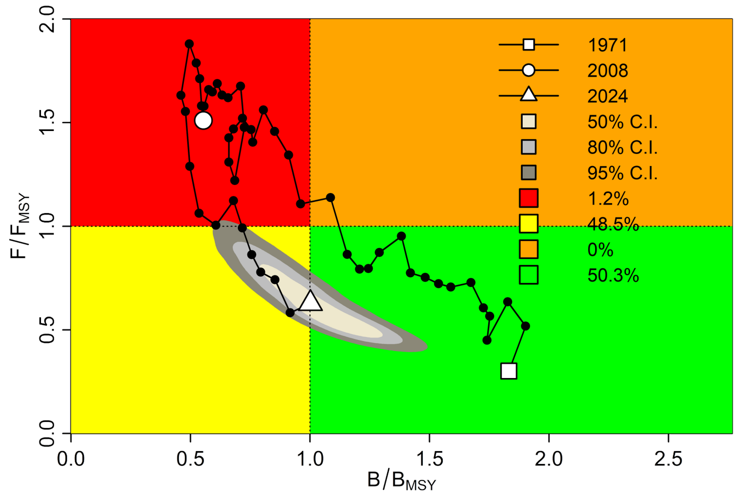
Table 4 Biomass assessment of three species groups in the Gulf of Thailand in 2023

Species group	Biomass in 2023 (tonne)	Biomass at MSY (tonne)	B/B_{MSY}
Demersal species	2,655,915	2,637,453	1.007
Pelagic fish	1,095,572	846,656	1.294
Anchovy	1,308,942	597,418	2.191

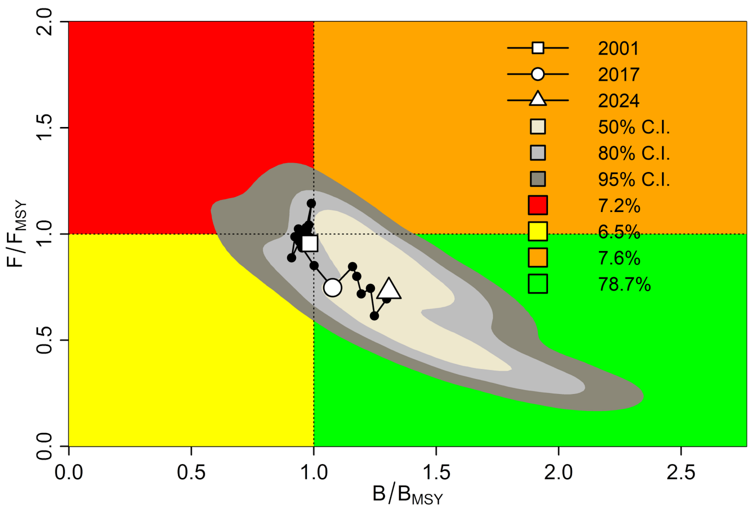
The results of single species assessment were consistent with species group assessment, showing that biomass of most species was higher than B_{MSY} (Table 4 and Appendix Table 7). Eight of the twelve demersal species had biomass levels higher than B_{MSY}. Shorthead anchovy, *Encrasicholina heteroloba*, which is the most dominant species in anchovy group, was selected for the biomass assessment. The biomass of the shorthead anchovy was the highest among the 17 selected species, reflecting the results of the species group assessment. However, the assessment of four pelagic fish species showed that the biomass of two species was lower than B_{MSY}, while two species were higher than B_{MSY}. Close monitoring of pelagic species is required, and additional pelagic species could be included in future assessments.

5.4.4 Catch from bottom-impacting gear types

Bottom-impacting fishing gear consists of pair trawl, otter board trawl, beam trawl, and clam dredges. The proportion of catch from the bottom-impacting fishing gears in the Gulf of Thailand between 2016 and 2021 ranged from 45.33% – 49.64% of the total catch. During 2022 – 2024, the catch from these gears showed a decreasing trend, accounting for 38.84% – 39.99% of the total catch. Pair trawl catch remained stable since 2016, while otter board trawl catch showed a decreasing trend from 162,728 tonnes in 2016 to 115,856 tonnes in 2024. Beam trawl and clam dredge catch contributed only few percentages of the total catch in the Gulf of Thailand and catch from both gears showed decreasing trends (Figure 4 and Appendix Table 8).



A)



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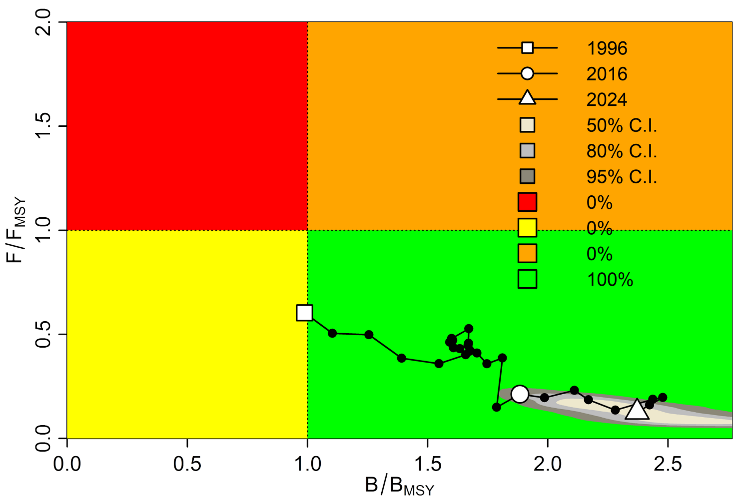

Figure 3 Stock assessment results in the Gulf of Thailand in 2024 using JABBA
A) Demersal species B) Pelagic fish C) Anchovy

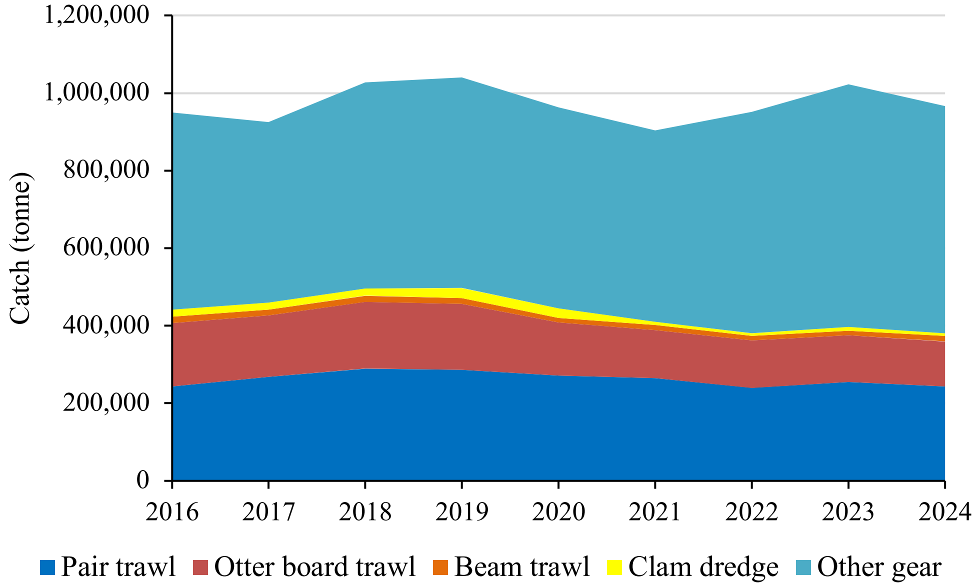

Figure 4 Catch by types of fishing gear (tonne) in the Gulf of Thailand between 2016 and 2024

5.4.5 Stock Status Plots

The assessment of fisheries resources using the Stock Status Plot method categorizes the status of resources into five levels: rebuilding, developing, exploited, over-exploited, and collapsed (Kleisner and Pauly, 2011). In terms of catch volume, the percentage of catch in the Gulf of Thailand from over-exploited stocks increased over time beginning in the late 1960s and reached a maximum of 58.4% of the total catch in 2008. After that, the catch from over-exploited stocks decreased continuously. The recent results in 2019 showed that majority of the catches, approximately 60% of the total catch in the Gulf of Thailand, came from healthy stocks either exploited, developing or rebuilding stocks. About 38% of the total catch came from over-exploited stocks, while 1% of the total catch came from collapsed stocks (Figure 5a) (Sea Around Us, 2025a).

In terms of number of stocks, the proportion of developing stocks decreased over time from about 70% in the early 1960s to 7% of the total number of stocks in 2019, whereas the number of over-exploited and collapsed stocks increased from 6.3% in 1970 to a maximum of 66.1% of the total number of stocks in 2011. After that, in 2019, the number of both stocks decreased to about 40%, and 60% of the total number of stocks was in either exploited, developing or rebuilding stocks (Figure 5b).

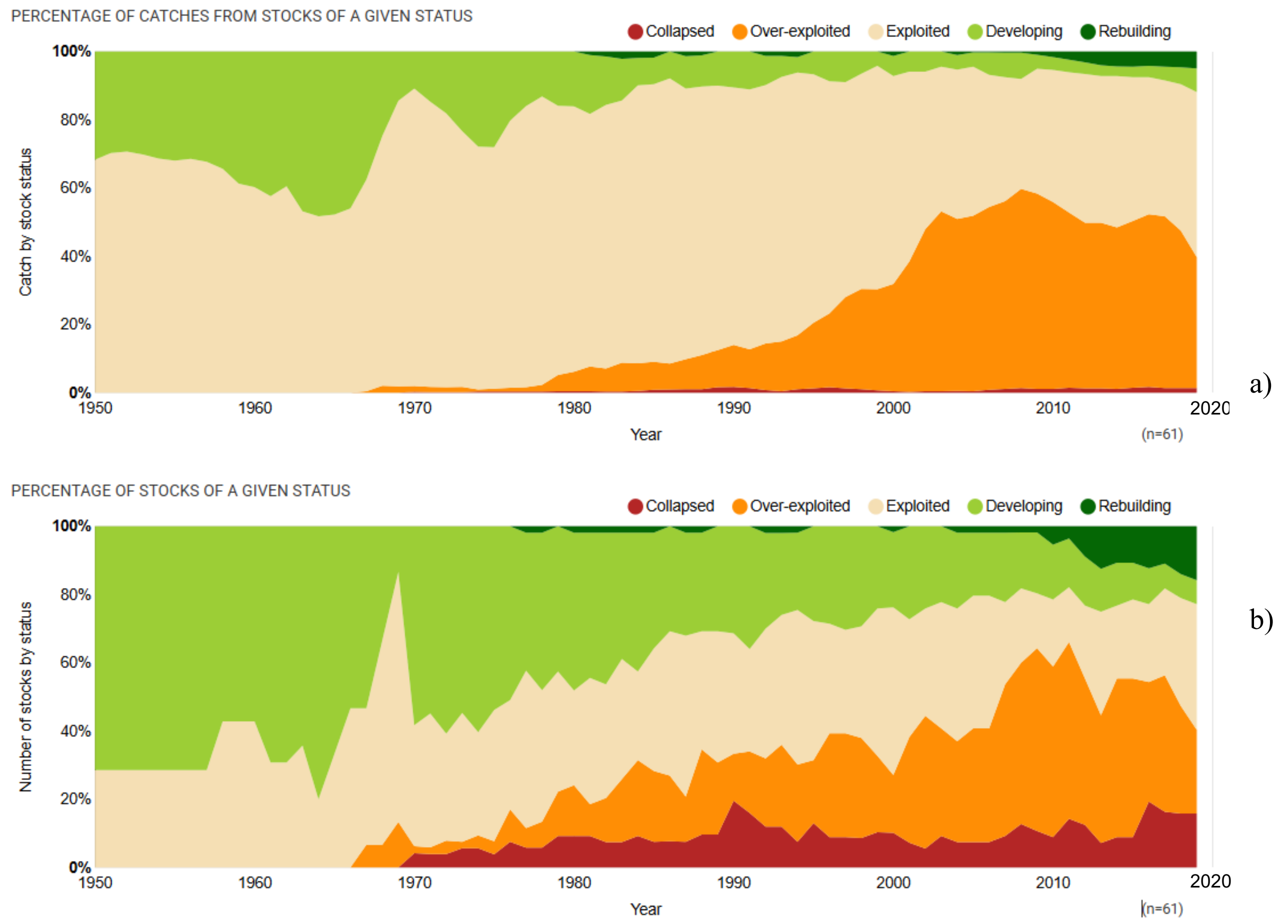

Figure 5 Results of Stock Status Plot in the Gulf of Thailand (Sea Around Us, 2025a)

a) percentage of catches from stocks of a given status

b) percentage of stocks of a given status

5.4.6 Primary Production Required for catches (PPR)

Key periods of change in the Primary Production Required (PPR) for catches in the Gulf of Thailand can be identified across several decades. During the 1950s and 1960s, PPR values were low and relatively stable, suggesting limited fishing pressure and a healthier equilibrium with the region's primary production. In contrast, the 1970s through the 1990s showed a steady and rapid increase in PPR, reaching the maximum PPR fraction of 2.67582 and reflecting the intensification of fishing activities. This increase was likely driven by the development of fisheries, an expansion in fleet capacity, and higher catch volumes. Between the 2000s and 2010s, PPR remained high and fluctuated, indicating ongoing and potentially unsustainable fishing pressure (Figure 6) (Sea Around Us, 2025b).

Ecologically, a PPR value exceeding 1% is typically viewed as a warning sign of possible ecosystem overfishing, as it suggests that fisheries are consuming a significant share of the ocean's primary production. In the Gulf of Thailand, PPR has far exceeded this threshold, which implies that the fishery may be ecologically unsustainable. This situation could result in a decline in fish stocks, trigger trophic cascades, and reduce the overall resilience of the marine ecosystem.

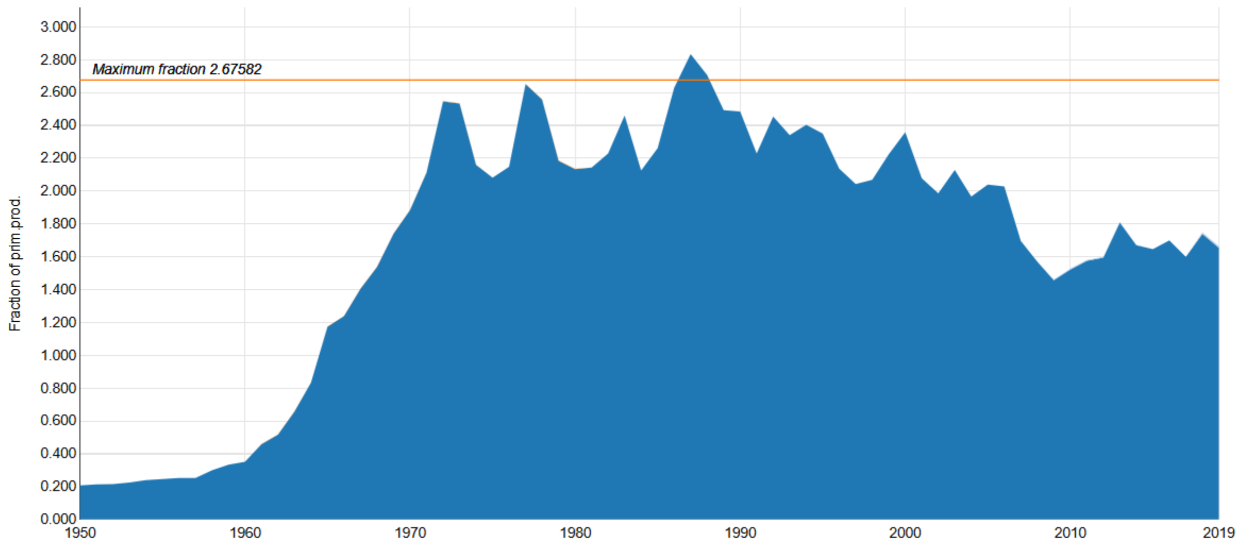

Figure 6 Primary Production Required for catches in the Thai waters of the Gulf of Thailand between 1950 and 2019 (Sea Around Us, 2025b)

5.4.7 Marine Trophic Index (MTI)

To calculate the Marine Trophic Index (MTI), fisheries resources in the Gulf of Thailand were classified into 39 groups with similar trophic levels based on their dietary habits and ecological roles. The trophic level for each species or group was calculated using diet composition data. The trophic levels were found to be as low as 2.1994 for shellfish, 2.3454 – 2.3458 for shrimp and prawn, and 2.5574 for trash fish. Coastal tunas, large piscivores (e.g. grouper), and sharks are among the top predators in the marine ecosystems, with trophic level exceeding 4.0000 (Appendix Table 9).

MTI was calculated for the period between 1990 and 2023. During the 1990s, the MTI was relatively high, exceeding 3.7600, and reached the maximum of 3.8462 in 1997. After that, MTI declined and dropped to its lowest value of 3.6959 in 2009. However, as a result of the implementation of the Royal Ordinance on Fisheries B.E. 2558 (2015), the MTI increased steadily and reached its highest level in 2023 at 3.7651, the highest value since 2000 (Figure 7).

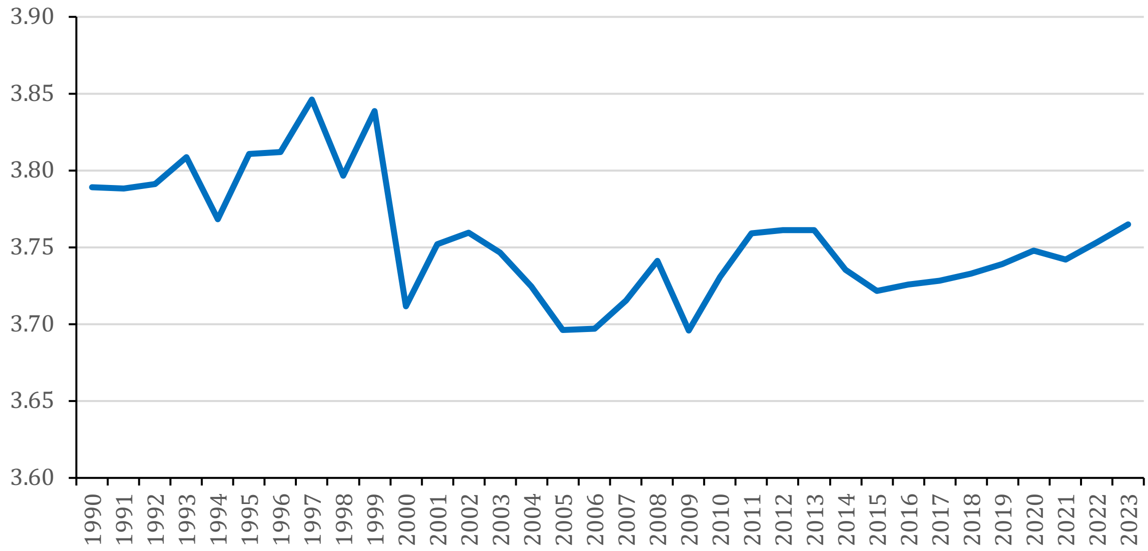

Figure 7 Marine Trophic Index (MTI) in the Gulf of Thailand between 1990 and 2023

5.5 Transboundary problems and issues

Fish stock assessment should be conducted covering the entire population of each species that share common biological characteristics, such as sharing common growth and mortality parameters. In addition, fisheries management requires comprehensive protection throughout the life cycle, requiring knowledge of spawning, nursery, and feeding grounds, etc. Management measures to conserve critical life stages, such as seasonal area closure in Thailand, still only consider migration routes and life history studies only in Thai waters. Several species in the Gulf of Thailand and the South China Sea are known to migrate across boundaries based on empirical knowledge; however, there is still a lack of clear research on the migration routes of aquatic animals in these regions. Therefore, studying the migration routes of aquatic animals in the Gulf of Thailand and the South China Sea is important for fisheries management, especially for highly migratory species such as neritic tunas.

Furthermore, after studying the stock status of transboundary species, these shared stocks require cooperative management. Management of transboundary species by any single country may not achieve sustainability targets or may only address part of the life cycle. Regional fisheries resource management may be implemented through the development of regional fisheries management plans.

5.6 Management and conservation efforts

The current management of Thai fisheries is governed by the Royal Ordinance on Fisheries B.E. 2558 (2015), which has been amended twice: the first is the Royal Ordinance on Fisheries (No. 2) B.E. 2560 (2017) and the second is the Act Amending the Royal Ordinance on Fisheries B.E 2558 (2015) B.E. 2568 (2025). The provisions of this Royal Ordinance aim to reorganize fisheries in Thailand to prevent IUU fishing in order to preserve aquatic animal resources as a sustainable source of food for humanity and preserve the environment in an appropriate state along the criteria and standards recognized internationally. The key principles and management measures under this law for the management of marine fisheries are shown in Appendix B.

5.7. Regional cooperation

5.7.1 ASEAN Network for Combating IUU Fishing (AN-IUU)

The ASEAN Network for Combating IUU Fishing (AN-IUU) was initiated by Thailand during its chairmanship of the ASEAN Summit in 2019, aiming to ensure the sustainability of aquatic resources across the region. The project gained momentum both nationally and regionally, with Thailand actively advocating for its establishment. Approval was granted at the Special Senior Officials Meeting of the 40th ASEAN Ministers on Agriculture and Forestry (SSOM-40th AMAF) in Vietnam on August 5, 2019, and it was subsequently endorsed at the 41st ASEAN Ministers' Meeting on Agriculture and Forestry in Brunei Darussalam on October 15, 2019. Thailand serves as the host for the Network Centre and manages the AN-IUU Interactive Platform, an online system for fisheries information exchange among member states.

The main objectives of AN-IUU are to facilitate the sharing of information related to illegal, unreported, and unregulated (IUU) fishing, to establish clear rules and procedures for information exchange, and to strengthen regional cooperation in combating IUU fishing. The ASEAN Secretariat and the Department of Fisheries, with support from the Enhanced Regional EU-ASEAN Dialogue Instrument (E-READI) and the Directorate-General for Maritime Affairs and Fisheries (DG-MARE), developed guidelines for sharing and accessing IUU fishing-related information. These guidelines were agreed upon at the 30th ASEAN Sectoral Working Group on Fisheries meeting in June 2022. To promote effective use of the AN-IUU Interactive Platform, training sessions have been organized for network coordinators from ASEAN Member States, allowing them to practice data exchange and system operations. Thailand has also expressed willingness to provide further training to member states to maximize the platform's effectiveness in joint surveillance and combating IUU fishing activities.

5.7.2 Regional Plan of Action to Promote Responsible Fishing Practices Including Combating IUU Fishing in the Region (RPOA-IUU)

The Regional Plan of Action to Promote Responsible Fishing Practices, Including Combating Illegal, Unreported, and Unregulated (IUU) Fishing in the Region (RPOA-IUU), was jointly initiated by the governments of Indonesia and Australia. The action plan was officially endorsed in Bali on May 4, 2007. Thailand, together with ten other participating countries—Australia, Brunei Darussalam, Cambodia, Indonesia, Malaysia, Papua New Guinea, the Philippines, Singapore, Timor-Leste, and Vietnam—engages in the RPOA-IUU on a voluntary basis. The primary objective of this initiative is to foster responsible fishing practices and to eliminate IUU fishing, with a particular emphasis on the South China Sea, the Sulu-Sulawesi Seas, and the Arafura-Timor Sea.

The RPOA-IUU is guided by a comprehensive work plan adapted from the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) framework. This work plan encompasses twelve core elements, including the implementation of legal instruments, promotion of international cooperation, and delineation of responsibilities among coastal, flag, port, and market states. Key activities under the RPOA-IUU include human resource development, capacity building, enhancement of monitoring, control, and surveillance (MCS) systems, and regulation of fish transshipment. Meetings under this framework routinely involve advisory contributions from regional fisheries organizations such as SEAFDEC, FAO, and INFOFISH. While participation remains voluntary, member states have consistently demonstrated a strong commitment to collaboration. A Coordination Committee has been established to oversee the implementation and progress of the action plan. These collective efforts have resulted in more robust and effective regional measures to combat IUU fishing and have promoted increased accountability in fisheries management.

5.7.3 Scientific Working Group on Neritic Tunas Stock Assessment in the Southeast Asian Waters (SWG-Neritic tunas)

The Scientific Working Group on Neritic Tunas Stock Assessment in Southeast Asian Waters (SWG-Neritic tunas) was established following the Expert Group Meeting on the Regional Plan of Action for Sustainable Utilization of Neritic Tuna Resources held in June 2014. SEAFDEC Member Countries nominated experts to join this group, and a formal Terms of Reference (ToR) was finalized in November 2014 and adopted in April 2015, with subsequent revisions in 2018 to expand its scope to additional species such as anchovy, sardines, and Indo-Pacific mackerel. The main objective of the working group is to foster regional cooperation among ASEAN Member States for effective stock assessment and management of neritic tunas and other important pelagic fishes, ensuring sustainable utilization of these resources in Southeast Asian waters.

The activities of the SWG-Neritic tunas include providing technical and scientific advice on the status of neritic tuna fisheries, recommending fisheries management policies, collecting and sharing catch and biological data for regional stock assessments, identifying human capacity needs within member countries, and coordinating with international and regional organizations for sustainable fisheries management. The group supports data collection, genetic studies, and related research to inform policy and management decisions, contributing to improved fisheries management and conservation throughout the region. The Eighth Meeting of SWG-Neritic tunas was the most recent meeting, which was held on 22 August 2024 via an online platform.

5.8. Recommendations and Priority Actions for Fisheries Management

Based on the current assessment of fisheries resource status, stock biomass, and governance gaps, the following priority actions are recommended to ensure the transition from stock stabilization to long-term sustainability and ecosystem resilience.

5.8.1 Enhancing the Efficiency of Fisheries Resource Assessments

To address current data gaps and improve the precision of Maximum Sustainable Yield (MSY) estimates, the following technical enhancements are required:

- **Integrate Primary Production Data:** Future stock assessments must incorporate **primary production** data for the Gulf of Thailand to refine MSY estimates. It is recommended to retrieve and digitize historical analog data from the Department of Fisheries (DOF) archives to construct a long-term productivity baseline that complements current catch data.
- **Single species assessment:** Currently, multispecies MSY, i.e., demersal species, pelagic fish, and anchovy, are used as reference points for fisheries management. Species that reflect the fishery based on inherent vulnerability, current

risk, ecological importance and management importance should be identified and assessed in addition to species group assessment, as part of monitoring program. Several indicators, e.g. biomass, length-based spawning potential ratio (LB-SPR), and yield-per-recruit (YPR), can be applied to single species assessment.

- **Reference Point for trash fish from trawls:** Half of the trawl catch consists of trash fish (reduction component), which includes juvenile economic species and true trash fish. These species are inevitably caught by trawl, so it is necessary to establish an appropriate reference point for the quantity of trash fish caught that does not disrupt the ecological balance or hinder the recovery of fisheries resource.

5.8.2 Policy Reforms and Governance Alignment

Management measures must evolve to address the complexities of multi-gear fisheries and the socio-economic reality of fishing communities.

- **Differentiated Management for Small-Scale Fisheries (SSF):** The Fisheries Action Plan must be realigned to reflect the local realities of the **artisanal sector**.

  Action: Develop a management plan for artisanal fisheries by applying the FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries to fit Thailand's economic, social, and resource conditions.

- **Managing Fishing Effort and Efficiency:** While the "Fishing Days" scheme has successfully addressed overfishing and stabilized CPUE of research vessels (stabilizing at ~16–21 kg/hr), the risk of **"effort creep"** (increased efficiency per day) remains.

  Action: Monitoring must expand beyond "days at sea" to track efficiency of fishing operations (e.g. net and fishing method modifications) that increase catch even when fishing time remains constant.

5.8.3 Adoption of Ecosystem Approach to Fisheries Management (EAFM)

- **Area-based Conservation in Vulnerable Zones:** EAFM principles must be operationalized in ecologically sensitive areas. Specific zones identified as critical nursing or spawning grounds (e.g., seagrass beds, coral reefs) require strict gear restrictions (e.g., banning bottom-impacting gears) to protect benthic habitats.
- **Ecosystem-based fisheries management:** Management measures under the current national fisheries management plan are based on multispecies MSY. To achieve ecosystem balance and increase ecosystem resilience to various pressures, such as fishing activities and climate change, it is important for the ecosystem to maintain a moderate level of resilience to adapt to these pressures. Ecosystem indicators and reference points should be incorporated in the next fisheries management plan.
- **Gear Selectivity:** accelerate the transition towards **selective fishing gears**. The dominance of "trash fish" (low trophic level species, trophic level ~2.55) in catches indicates continued ecosystem alteration. Incentives should be introduced to install bycatch reduction devices on trawls and to replace non-selective trawls with more selective gears (e.g., traps, specific mesh-size gillnets) to reduce bycatch of juveniles.

5.8.4 Enhancing Regional Cooperation (Transboundary Management)

One of the key principles for fish stock assessment is that it should cover the whole populations of the same species with similar biological characteristics. Given the semi-enclosed nature of the Gulf of Thailand, national efforts alone are insufficient for managing migratory stocks.

- **Joint Management of Transboundary Species:** Immediate steps should be taken to establish joint management plans for economically critical transboundary species, specifically **neritic tunas (*Thunnus* spp., *Euthynnus* spp., *Auxis* spp.), and Spanish mackerel and king mackerel (*Scomberomorus* spp.)**.
- **Regional Mechanisms:** Thailand should leverage the Promoting the Blue Economy and Strengthening Fisheries Governance of the Gulf of Thailand through the Ecosystem Approach to Fisheries (GoTFish) Project as a platform to harmonize stock assessment methodologies and data sharing protocols with neighboring countries (Cambodia, Vietnam, and Malaysia).

Action Plan:

1. Conduct joint stock assessments for shared stocks to determine a regional Total Allowable Catch (TAC).
2. Harmonize adaptive closed seasons based on migratory and biological studies to protect critical life stages
3. Develop a regional fisheries management plan, particularly for transboundary species

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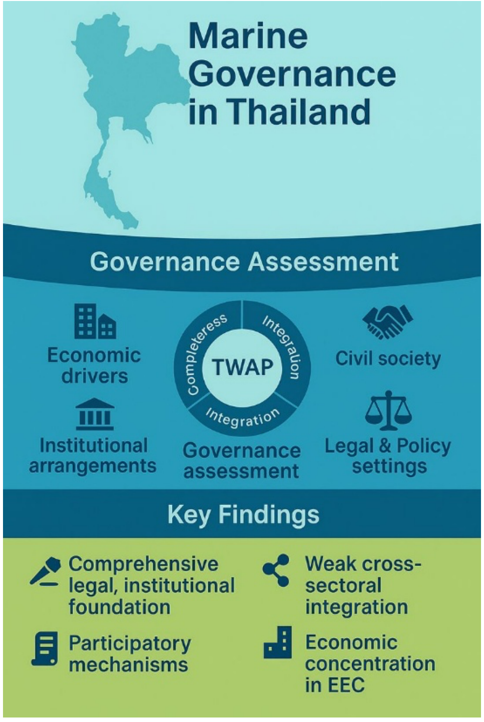
VI. Governance

Abstract

Thailand’s coastal and marine governance plays a central role in safeguarding ecosystems, supporting national development, and managing transboundary risks within the South China Sea (SCS) region. This report assesses the current status of Thailand’s governance arrangements by examining economic drivers, institutional structures, legal and policy frameworks, and mechanisms for civil society participation. Using the Transboundary Water Assessment Programme (TWAP) Governance Architecture Assessment Framework—covering completeness, integration, and engagement—the assessment identifies areas of progress and persistent governance constraints.

Findings show that Thailand has established a comprehensive legal and institutional foundation for coastal and marine resource management, including national committees, sectoral legislation, and long-term policy planning. Stakeholder engagement mechanisms, including provincial committees and community-based groups, provide additional support for participatory governance. However, weak cross-sectoral integration, uneven provincial implementation capacity, and limited alignment between climate policy, coastal development, and marine resource management continue to hinder effective decision-making and adaptive responses. Economic concentration in the Eastern Economic Corridor (EEC) further heightens governance asymmetries and ecological pressures.

The report concludes that strengthening policy coherence, climate governance, provincial capacity, and regional cooperation is essential for improving Thailand’s readiness to address emerging environmental challenges and transboundary risks across the SCS Large Marine Ecosystem.



Marine Governance in Thailand: Key Components and Assessment Overview

This infographic summarises the core components of Thailand's marine governance system and the results of the national self-assessment using the TWAP Governance Architecture Assessment Framework. The upper panel highlights the geographic scope of marine governance within Thailand. The middle panel presents four foundational governance elements—economic drivers, institutional arrangements, civil society engagement, and the legal and policy setting—together with the TWAP assessment wheel illustrating scores for completeness, integration, and engagement. The lower panel synthesises the key findings: Thailand has a comprehensive legal and institutional foundation and well-established participatory mechanisms, but governance effectiveness is constrained by weak cross-sectoral integration and economic concentration in the Eastern Economic Corridor (EEC). Together, these components illustrate the strengths and persistent gaps shaping Thailand's capacity for effective coastal and marine governance.

6.1 Key findings

6.1.1 Economic arrangements

The Gulf of Thailand is a core economic engine, contributing roughly 60–65% of national GPP through industry, tourism, fisheries, and logistics. Rapid expansion under the Eastern Economic Corridor (EEC) has intensified pressures on coastal ecosystems via land conversion, pollution, habitat loss, and overexploitation. Strong economic disparities among provinces result in uneven capacity for marine resource management, with EEC provinces far better resourced than lower-income coastal areas.

6.1.2 Institutional setting

Thailand has a complex institutional structure involving multiple ministries, agencies, and cross-sectoral committees. While DMCR holds the primary mandate, effective governance depends on coordination with DOF, DNP, ONEP, PCD, DCCE, MD, and RTN. Despite strong national arrangements, coordination remains fragmented and provincial implementation capacity varies. Provincial committees continue to face weak integration, irregular operations, and limited participation of small-scale fishers and women.

6.1.3 Legal and policy framework

Thailand possesses a comprehensive legal and policy framework aligned with key international commitments (UNCLOS, CBD, GBF, SDG 14). Core instruments include the Marine and Coastal Resources Management Act (2015), Fisheries Ordinance (2015), Environmental Quality Act, Climate Change Master Plan, NBSAPs, and the National Marine and Coastal Resources Management Plan (2023–2027). However, enforcement gaps persist, and pending legislation (Climate Change Act and National Biodiversity Act) constrains long-term legal certainty.

6.1.4 Civil society, stakeholders, and partnerships

Thailand is highly active in regional and global marine governance platforms (e.g., UNEP/COBSEA, ASEAN, APEC, IOC/WESTPAC, IORA), with DMCR playing a central leadership role. At the local level, however, participation remains uneven. Women and marginalized groups have limited influence, and community engagement is strongest when supported by long-term donor or academic partnerships.

Overall finding

Thailand demonstrates strong national policy frameworks and active regional engagement, but persistent implementation gaps—driven by institutional fragmentation, economic disparities, and uneven provincial capacity—pose ongoing governance risks. Strengthening cross-sectoral coordination, inclusive participation, legal coherence, and sustainable financing is essential for effective governance of marine and coastal resources in the Gulf of Thailand.

6.2 Current Status

6.2.1Economic arrangements

The Gulf of Thailand covers approximately 200,000 km² with a coastline of about 2,000 km across 17 coastal provinces from Trat to Narathiwat. It contains highly productive ecosystems, including coral reefs, mangroves, and seagrass beds, that underpin food security, biodiversity conservation, and coastal livelihoods (DMCR, 2013). These ecosystems also support Thailand's major marine-based industries, including fisheries, tourism, maritime transport, seafood processing, energy, and emerging blue economy activities. The total annual value of Thailand's marine and coastal ecosystems (Gulf of Thailand and Andaman Sea combined) is estimated at approximately THB 24 trillion (USD 742 billion), including both direct economic services and indirect ecosystem services such as coastal protection and carbon sequestration (Sub-Committee on Knowledge Management for Marine National Interests, 2019).

Over the past two decades, marine resource use in the Gulf of Thailand has intensified alongside rapid economic development. Key drivers include the Eastern Economic Corridor (EEC), coastal urbanization, and expansion of marine tourism. Since its launch in 2017, the EEC has transformed Chonburi, Chachoengsao, and Rayong into major industrial and logistics hubs, driving large-scale port development, industrial estates, and coastal land conversion. While these investments have strengthened national economic growth, they have also contributed to significant environmental degradation, including mangrove loss, coral and seagrass decline, overfishing, and increasing marine pollution (Sub-Committee on Knowledge Management for Marine National Interests, 2019).

National budget allocations and rising domestic and foreign investments continue to shape infrastructure and industrial development across the Gulf, with marked variation among provinces. Given the scale of economic pressure on marine ecosystems, strengthening sustainable financing mechanisms and improving integration between economic and environmental policies are essential to support long-term conservation, ecosystem restoration, and the sustainable use of marine and coastal resources in the Gulf of Thailand.

6.2.1.1 Policy and Economic Drivers

Policy drivers

Economic development policies and political priorities strongly shape marine and coastal resource use in the Gulf of Thailand, a national hub for industry, tourism, and fisheries. Over the past two decades, development has been guided by the National Economic and Social Development Plans and the 20-Year National Strategy, which promote economic competitiveness alongside environmental sustainability. Key policy drivers include the bio-economy and marine tourism, industrial and port expansion under the Eastern Economic Corridor, and environmental strategies such as the Blue Economy, Bio-Circular-Green (BCG) Economy, and Marine Spatial Planning.

While these policies have supported economic growth, rising incomes, and poverty reduction, they have also intensified pressures on marine ecosystems. Significant impacts include mangrove loss, coral and seagrass degradation, declining fish stocks, and increasing marine pollution from industrial and shipping activities (PEMSEA & DMCR, 2019; DMCR, 2024). These trends underscore the need for stronger institutional accountability and sustained financing for ecosystem protection and restoration.

Economic drivers

Over the past two decades (2000–2024), Thailand's economy has been shaped by a wide range of dynamics. These include domestic factors such as political uncertainty, constitutional reforms, and multiple changes in government, as well as external influences such as global economic fluctuations, trade tensions among major powers, and the COVID-19 pandemic. All of these have had significant impacts on the country's overall economic growth.

a) Thailand's Overall Economic Situation (2000–2024)

Over the past two decades, Thailand's economy has expanded substantially, with GDP increasing from USD 126.4 billion in 2000 to USD 526.4 billion in 2024, while GDP per capita rose from USD 1,967 to USD 7,345 (Figures 1–2; Annex 1). Over the same period, the national poverty rate declined sharply from 61% to about 10%, reflecting significant improvements in living standards and economic resilience. Thailand is currently classified as an upper-middle-income country based on GNI per capita, and poverty reduction has been largely consistent with this income transition (World Bank, 2025).

b) Economic Profile of the Gulf of Thailand Region

The Gulf of Thailand spans 17 coastal provinces across the eastern, upper, western, and lower Gulf zones. Together, these provinces form a major economic corridor supporting industry, marine and coastal tourism, fisheries, seafood processing, and maritime logistics. The region is therefore a strategic hub for national and international trade and a major contributor to Thailand's GDP and employment (Annex 2).

c) GPP and Regional Economic Contribution

From 2000–2023, the Gulf of Thailand consistently contributed about 60–65% of Thailand's national GPP, increasing from USD 80.25 billion to USD 324.49 billion. Bangkok alone accounted for roughly 32% of national GPP, while the remaining Gulf provinces contributed about 30%. The Eastern Economic Corridor (EEC) provinces—Chonburi, Rayong, and Chachoengsao—emerged as key growth centers driven by strong public and private investment, confirming the Gulf's central role in Thailand's industrial, logistics, fisheries, and tourism economy (Figure 3).

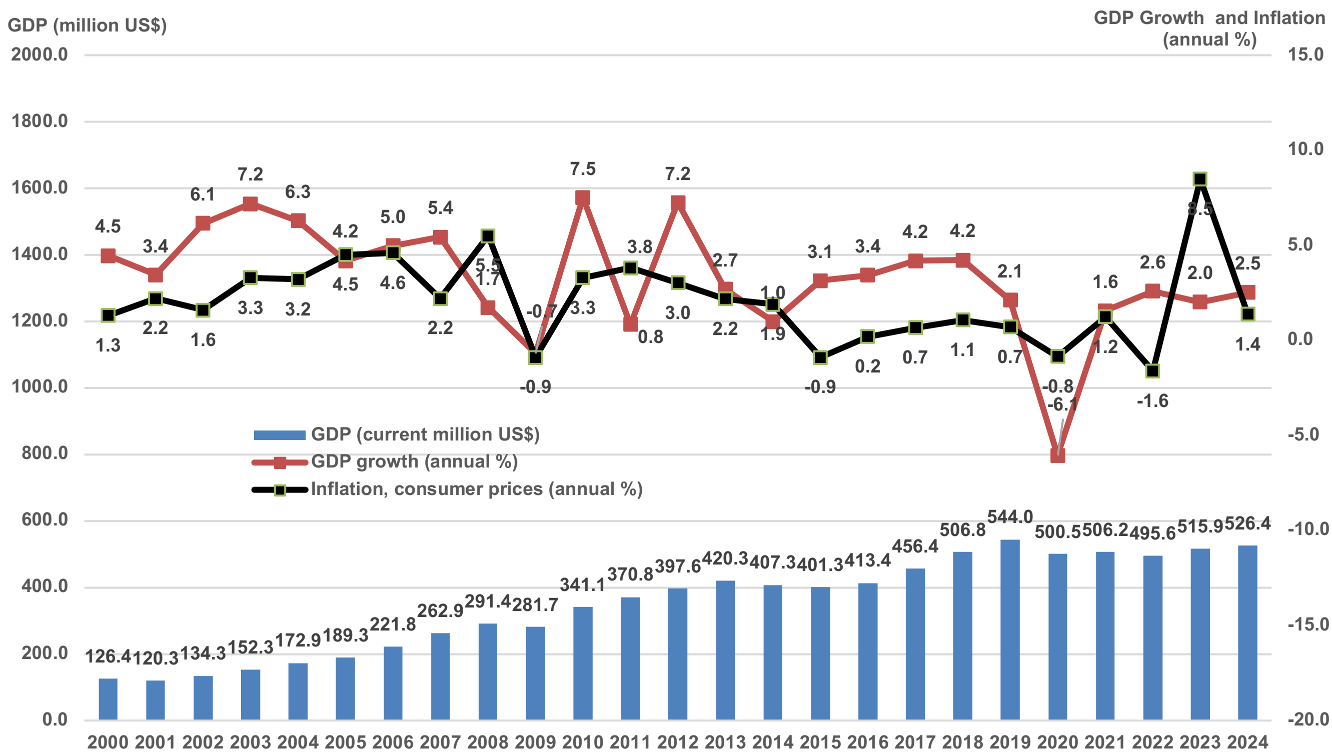


Figure 1: GDP, GDP growth rate, and inflation rate 2000-2023.

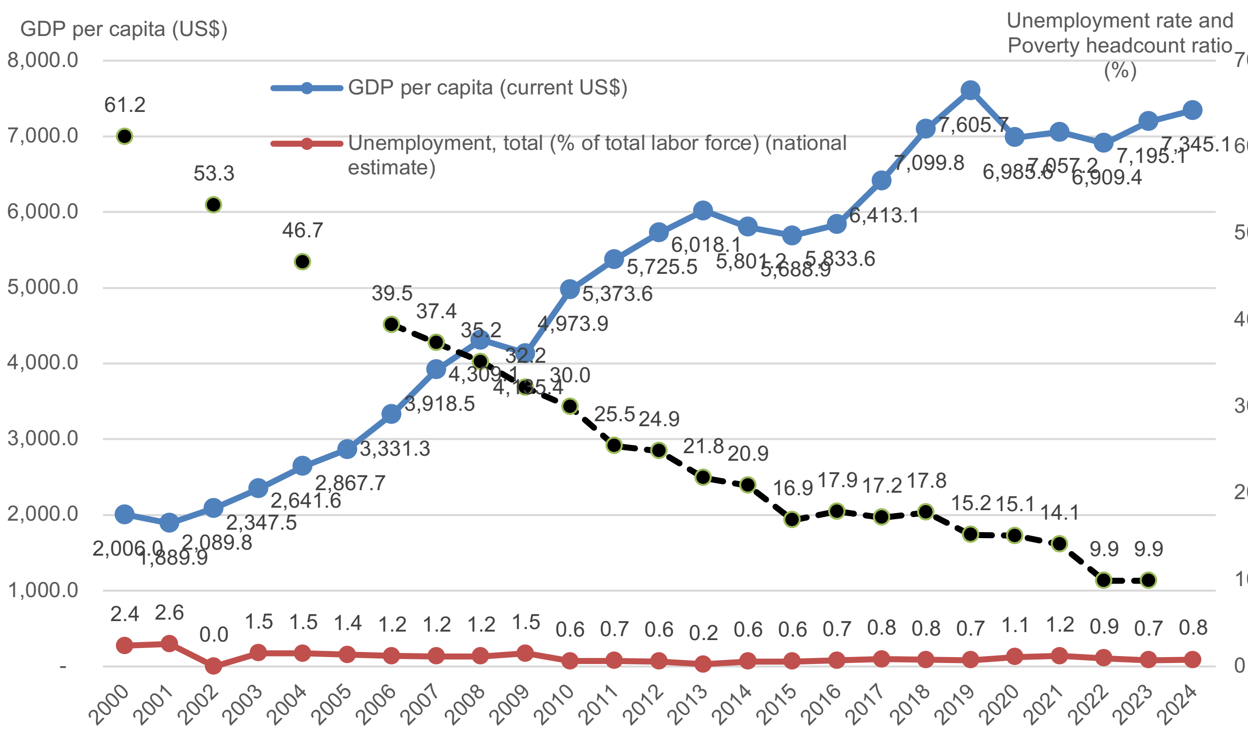
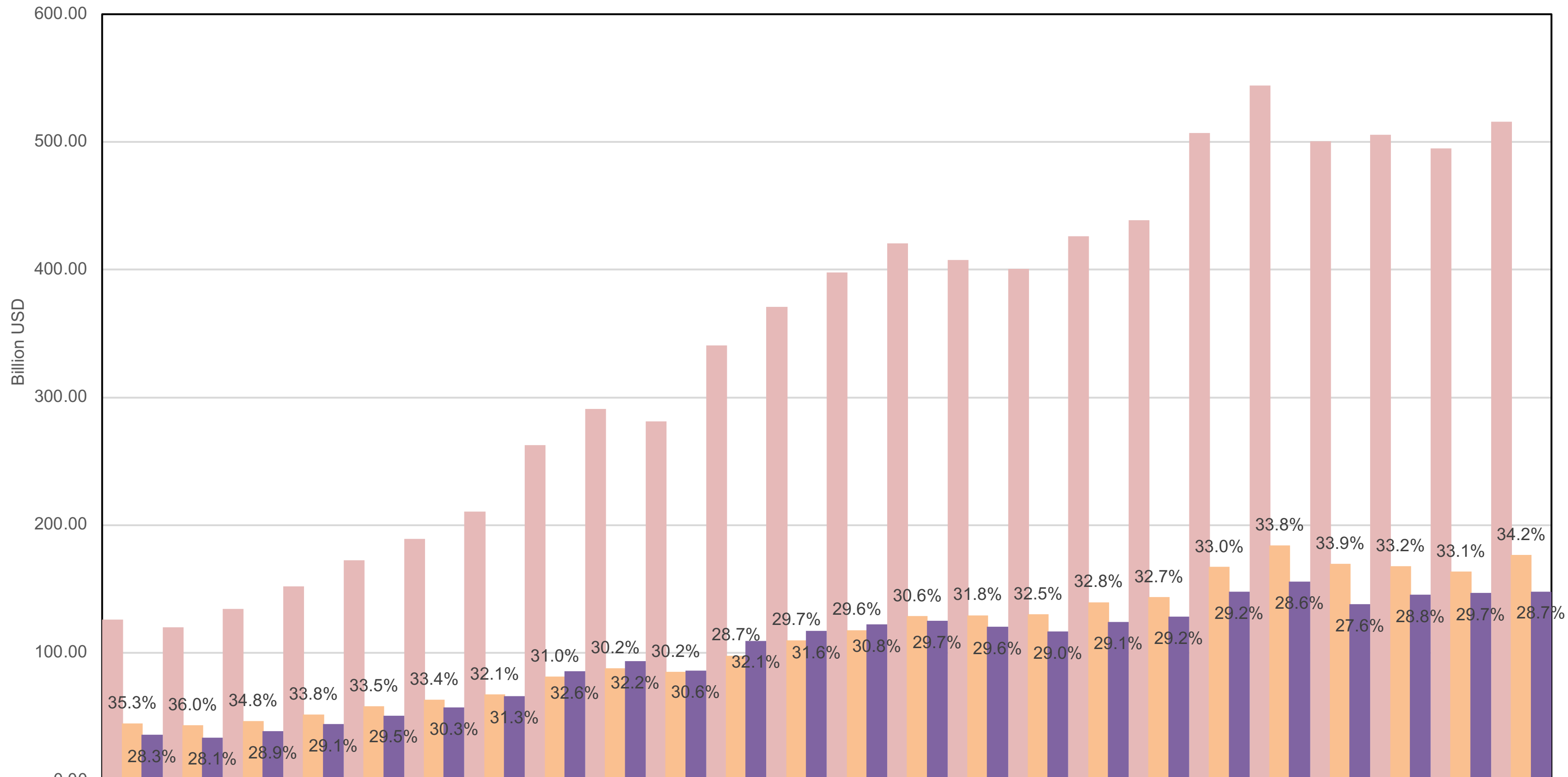


Figure 2: GDP per capita, unemployment rate, and poverty headcount ratio 2000-2023.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Whole Kingdom	126.24	120.17	134.18	152.11	172.69	189.08	210.38	262.62	290.98	281.27	340.63	370.84	397.60	420.69	407.34	400.8	426	438.9	506.91	544.11	500.36	505.83	495.1	515.94
Bangkok	44.52	43.26	46.63	51.46	58.09	63.07	67.55	81.43	87.80	85.06	97.82	109.95	117.76	128.86	129.44	130.29	139.59	143.72	167.46	184.01	169.63	167.67	163.73	176.52
16 Others provinces	35.73	33.70	38.72	44.19	50.97	57.33	65.86	85.67	93.54	85.91	109.43	117.27	122.30	125	120.52	116.49	124.15	128.26	147.84	155.66	137.88	145.54	146.82	147.97

Figure 3 Gross Provincial Product of Gulf of Thailand (Billion USD), 2000-2023 (Data retrieved from Office of the National Economic Social and Development Council (NESDC): https://www.nesdc.go.th/main.php?filename=gross_regional

Provincial Economic Stratification and Implications for Marine Governance

Based on 2023 GPP, GPP per capita, and poverty data (Annex 3), coastal provinces along the Gulf of Thailand can be grouped into three economic tiers with distinct governance implications.

High-GPP provinces (Chonburi, Rayong, Samut Prakan, Chachoengsao, Samut Sakhon), largely within the Eastern Economic Corridor (EEC), function as Thailand's primary industrial and logistics hubs, with high per capita income and very low poverty rates. These provinces generally possess stronger fiscal and institutional capacity for marine management.

Medium-GPP provinces (Songkhla, Surat Thani, Nakhon Si Thammarat) exhibit diversified economies combining tourism, agriculture, and light industry, with moderate income levels and transitional development patterns.

Low-GPP provinces (Chanthaburi, Phetchaburi, Prachuap Khiri Khan, Trat, Chumphon, Samut Songkhram, Pattani, Narathiwat) remain highly dependent on fisheries, agriculture, and nature-based tourism, with limited industrial investment and weaker fiscal capacity. Pattani and Narathiwat face persistently high poverty linked to security constraints.

These economic disparities translate into unequal institutional readiness for sustainable marine governance. Wealthier provinces are better positioned to finance conservation and enforcement, while lower-income provinces face constraints in planning, monitoring, and ecosystem restoration. Targeted fiscal support and context-specific financing mechanisms are therefore essential to ensure equitable and effective marine governance across the Gulf of Thailand (PEMSEA & DMCR, 2019).

6.2.1.2 National Budgetary Allocations

Marine and coastal resource management in the Gulf of Thailand is essential for Thailand's economic and environmental security. However, the government's capacity to sustain long-term investment in marine conservation is closely linked to national fiscal conditions and current account performance.

Thailand's fiscal position has undergone major shifts over the past two decades (Figure 4). Following the recovery from the 1997–1998 financial crisis, fiscal balances stabilized during 2003–2019, with deficits generally remaining below 3% of GDP, except during the 2009 global financial crisis. The COVID-19 pandemic caused a sharp deterioration, with deficits widening to –4.5% to –7.1% of GDP between 2020 and 2022. Public debt rose rapidly from below 40% of GDP before 2020 to over 60% in 2023. Although debt remains below the national ceiling, fiscal pressures have increased.

Thailand maintained strong current account surpluses until 2019, but shifted into deficit during 2020–2022 due to the collapse of tourism revenues. Surpluses returned in 2023–2024 with tourism and export recovery, but overall fiscal space remains constrained.

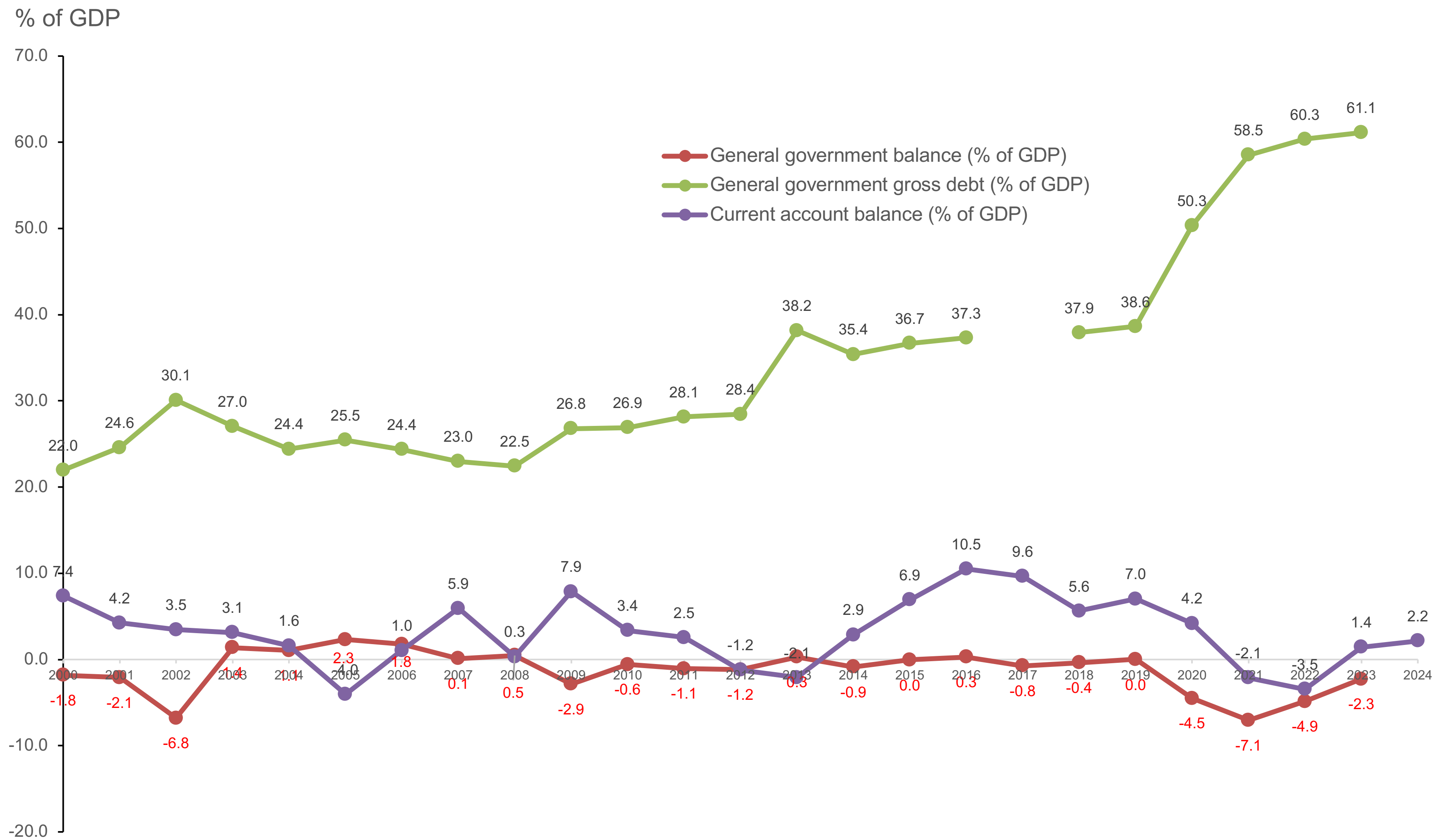


Figure 4 General government balance, general government debt, and current account of Thailand, 2000-2024.

These fiscal trends directly affect the government's ability to finance marine conservation, ecosystem restoration, and sustainable fisheries management in the Gulf of Thailand. During the COVID-19 period, budget priorities shifted toward economic recovery, delaying investments in long-term environmental protection. Although economic recovery is underway, limited fiscal space continues to pose challenges for sustained and proactive marine resource management.

Budget Allocation of Government Agencies Related to Marine Resources

Thailand's marine resource management depends heavily on continued public budget support to sustain conservation, restoration, and regulatory functions amid growing pressures from climate change, coastal development, fisheries, and tourism. The Department of Marine and Coastal Resources (DMCR) is the lead agency for marine and coastal management, working alongside the Department of National Parks, Wildlife and Plant Conservation (DNP) and the Department of Fisheries (DOF), whose mandates cover protected areas and fisheries nationwide. Effective governance, therefore, requires strong financial and strategic coordination across these agencies.

Budget data for 2013–2024 show that DMCR consistently receives a smaller allocation than DNP and DOF, despite its central marine mandate. DMCR's budget rose from USD 36.3 million in 2013 to USD 51.16 million in 2024, while DNP and DOF received substantially higher funding, reaching USD 315.37 million and USD 104.49 million in 2024, respectively (Figure 5).

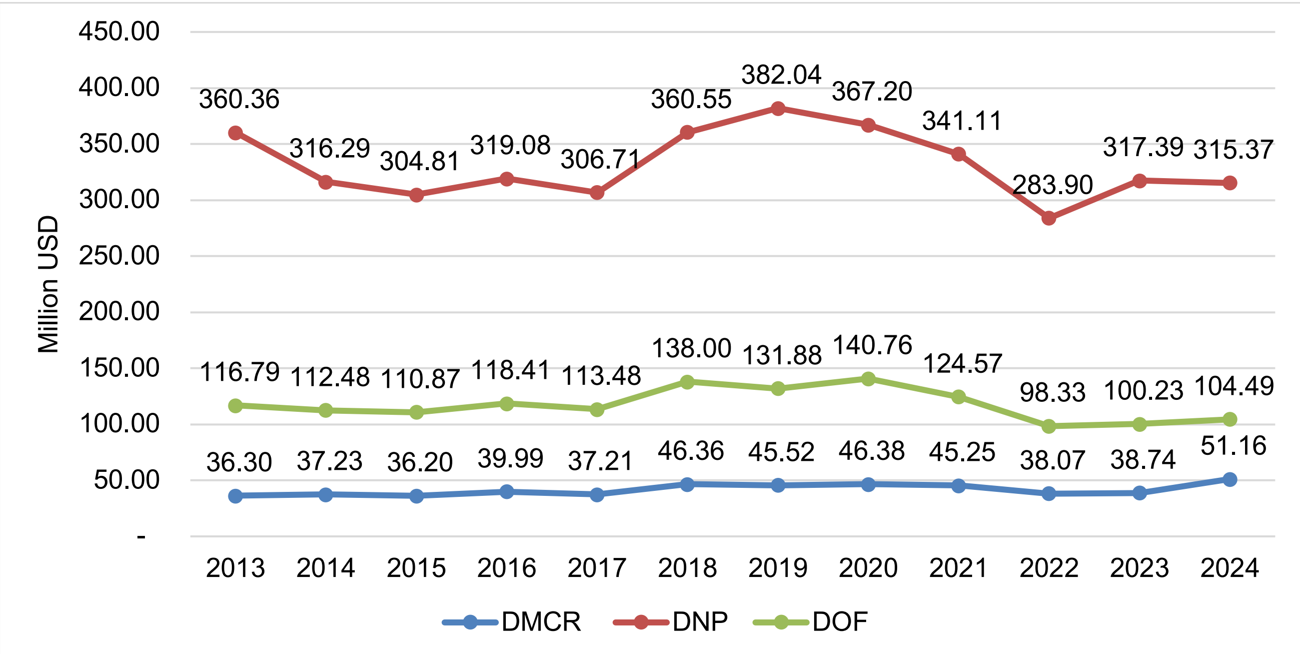


Figure 5: Budget Allocations for Agencies Involved in Marine Resource Management in Thailand, 2013–2024 (Source: *Annual Budget Expenditure Documents under the Budget Appropriation Acts for Fiscal Years 2013–2023,* Bureau of the Budget, Office of the Prime Minister. https://www.bb.go.th/index.php)

Given ongoing fiscal constraints, ensuring reliable financing for marine governance remains a critical challenge. Beyond public funding, greater use of Public–Private Partnerships (PPPs) and innovative instruments such as blue funds, blue bonds, and blue carbon credits will be essential to strengthen the long-term financial sustainability of marine conservation in Thailand.

6.2.1.3 National and International Investments (Domestic direct investment and Foreign direct investment)

The Gulf of Thailand continues to attract strong domestic and foreign direct investment (DDI/FDI) due to its strategic location and economic potential. Between 2015 and 2024 (Annex 4), Thailand became increasingly reliant on FDI, which rose from 61% to 74.7% of total investment (BOI).

The Eastern Economic Corridor (EEC) is the dominant investment zone, attracting USD 10.45 billion in 2023, mainly in electronics, machinery, automotive, petrochemicals, EVs, and logistics. Major infrastructure projects further strengthen regional connectivity.

However, both FDI and DDI generate significant environmental pressures, including port expansion, land reclamation, industrial wastewater discharge, and coastal erosion. Strengthened environmental safeguards, community participation, and sustainable finance mechanisms are essential to balance economic growth with long-term ecosystem protection.

6.2.1.4 Provincial Investments

Provincial investment along the Gulf of Thailand shows strong spatial inequality, reflecting uneven development across coastal provinces. Based on 2024 data from the Board of Investment (BOI) and the Department of Business Development (DBD) (Annex 5), investments can be grouped into high-, medium-, and low-investment provinces, revealing distinct regional development patterns.

High-investment provinces—Rayong, Chonburi, Samut Prakan, and Chachoengsao—account for approximately 94% of total investment in the Gulf of Thailand. These provinces form the economic core of the Eastern Economic Corridor (EEC) and function as national industrial and logistics hubs. Rayong and Chonburi dominate large-scale foreign direct investment in petrochemicals, energy, and manufacturing, while Samut Prakan and Chachoengsao show strong growth in both industrial and local business registration. Together, these provinces serve as the primary growth poles of the Gulf region and are deeply integrated into global supply chains.

Medium-investment provinces, including Samut Sakhon, Phetchaburi, Songkhla, Nakhon Si Thammarat, Chumphon, Surat Thani, and Prachuap Khiri Khan, show a mixed economic structure combining agriculture, seafood processing, and coastal tourism. These provinces function as emerging economic hubs, with moderate investment potential that depends on improved infrastructure, logistics connectivity, and market access.

Low-investment provinces—Trat, Chanthaburi, Samut Songkhram, Pattani, and Narathiwat—remain resource-dependent economies, dominated by agriculture, small-scale fisheries, and eco-tourism. These areas face persistent constraints, including weak infrastructure, small markets, and security challenges in the southern border provinces, limiting their ability to attract both domestic and foreign investment.

Overall, provincial investment patterns reveal high economic concentration in the EEC provinces and structural vulnerability in peripheral coastal areas. These disparities directly affect provincial capacity for environmental management and sustainable marine governance. High-investment provinces exert intense development pressure on coastal ecosystems, while low-investment provinces face financial and institutional constraints in conservation and restoration. This underscores the need for spatially targeted investment policy, equitable budget allocation, and differentiated governance strategies to support sustainable blue economy development across the entire Gulf of Thailand.

6.2.2 Institutional Setting

6.2.2.1 Institutions, Regulatory Agencies, Administrative Arrangements

Thailand's marine and coastal governance operates through a multi-level institutional system involving sectoral agencies, inter-ministerial coordination mechanisms, and national policy committees. The Department of Marine and Coastal Resources (DMCR), under the Ministry of Natural Resources and Environment (MONRE), holds the primary mandate for coastal and marine resource management. It works closely with key MONRE agencies (Fig 6), including the Department of National Parks, Wildlife and Plant Conservation (DNP), Pollution Control Department (PCD), Office of Natural Resources and Environmental Policy and Planning (ONEP), Department of Climate Change and Environment (DCCE), and Department of Mineral Resources (DMR), which together support ecosystem protection, environmental regulation, and climate policy implementation.

Beyond MONRE, several sectoral agencies play critical roles. The Department of Fisheries (DOF) under the Ministry of Agriculture and Cooperatives leads fisheries and aquaculture management; the Royal Thai Navy (RTN) is responsible for maritime security and IUU fishing enforcement; the Marine Department (MD) regulates navigation and ports; the Department of Industrial Works (DIW) oversees industrial pollution control; and the Ministry of Foreign Affairs (MFA) coordinates Thailand's international marine governance engagement (Annex 6).

Policy integration is guided by several national committees, including the Maritime Interests Protection Policy Committee (MIP), Marine and Coastal Resources Committee (NMCRC), National Environment Board (NEB), National Biodiversity Committee (NBC), National Climate Change Policy Committee (NCCP), National Pollution Control Committee (NPC), and National Fisheries Committee (NFC), supported by technical subcommittees (Annex 7). These bodies formulate policy recommendations that are consolidated and submitted to the Cabinet for approval, ensuring alignment across sectors.

As Marine Spatial Planning (MSP) advances, the MIP and NMCRC play leading strategic roles in integrating the National MSP Framework into legal and policy instruments, supported by specialized subcommittees (World Bank, 2025). Overall, Thailand's institutional framework provides a strong national governance backbone; however, coordination gaps and uneven provincial implementation continue to constrain fully integrated and effective marine and coastal governance.

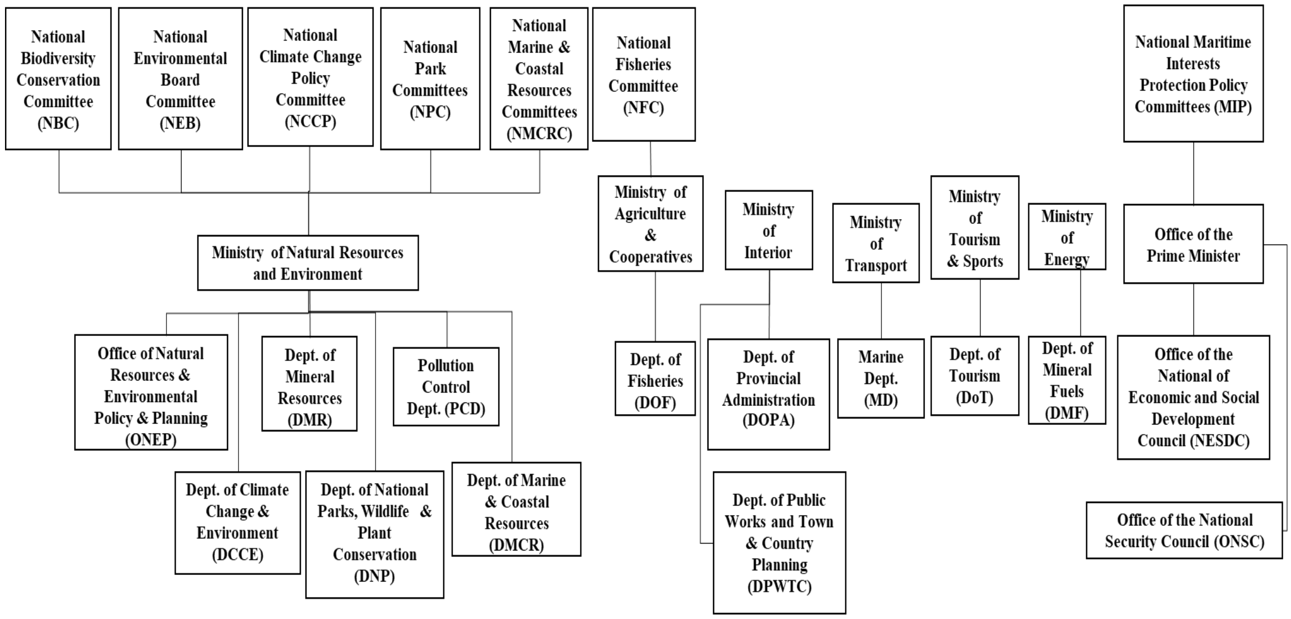


Figure 6. Government agencies and policy committees relevant to governing marine and coastal resources in Thailand

6.2.2.2 Regional Governance, Bilateral and Multilateral Engagement

The Department of Marine and Coastal Resources (DMCR) plays a central role in advancing Thailand's regional and international engagement for sustainable marine and coastal governance. Through active participation in global, regional, and bilateral cooperation frameworks, Thailand aligns national marine management with international commitments, including the 2030 Agenda for Sustainable Development, the Kunming–Montreal Global Biodiversity Framework (GBF), and the UN Decade of Ocean Science (2021–2030).

At the global level, DMCR cooperates closely with key international organizations such as UNESCO, IOC, UNEP, IOI, and CMS, supporting marine science, biodiversity conservation, marine litter management, protection of migratory species, and capacity development. Thailand also participates in major international legal and policy processes, including the BBNJ Agreement under UNCLOS, enhancing its role in global ocean governance.

At the regional level, Thailand is actively engaged through ASEAN, COBSEA, APEC, and the Indian Ocean Rim Association (IORA), contributing to regional initiatives on marine pollution control, climate change adaptation, sustainable fisheries, blue economy development, and marine scientific cooperation. DMCR further strengthens regional integration through leadership roles in ASEAN working groups and technical subcommittees related to coastal and marine environments.

Bilateral and innovation-based partnerships also support Thailand's marine governance, particularly through public–private collaboration on marine debris management and technological solutions for pollution reduction.

Overall, Thailand's extensive engagement across multilateral, regional, and bilateral platforms reflects a strong commitment to cooperative, science-based, and integrated ocean governance. These partnerships enhance Thailand's technical capacity, regional leadership, and contribution to sustainable marine and coastal management in the South China Sea and the wider Indo-Pacific region (see Annex 8).

6.2.3 Legal and Policy Setting

Thailand's marine and coastal governance is underpinned by a comprehensive legal and policy framework that integrates international obligations, regional cooperation, and national implementation. These instruments define mandates, principles, and mechanisms for addressing key challenges such as biodiversity conservation, marine pollution, climate change, and sustainable resource use. Thailand's frameworks are closely aligned with global commitments, including the 2030 Agenda for Sustainable Development, the Kunming–Montreal Global Biodiversity Framework (GBF), and the UN Decade of Ocean Science for Sustainable Development (2021–2030).

6.2.3.1 International Legal and Policy Frameworks

Thailand is Party to major international conventions governing biodiversity, pollution, and climate change (Annex 9). Biodiversity governance is guided by the Convention on Biological Diversity (CBD) and the GBF, including the 30x30 marine protection target. Additional instruments include the Ramsar Convention, CITES, the World Heritage Convention, and the Convention on Migratory Species (CMS), supporting protection of wetlands, endangered species, and migratory marine fauna.

Marine pollution and maritime governance are shaped by UNCLOS, MARPOL, the London Convention, Basel Convention, OPRC, Rotterdam Convention, and Stockholm Convention. Climate governance is guided by the UNFCCC, Kyoto Protocol, Paris Agreement, Montreal Protocol, and UNCCD, forming the basis for mitigation, adaptation, and ecosystem-based resilience in coastal systems. Thailand integrates these obligations into national laws and action plans.

6.2.3.2 Regional Legal Policy Frameworks and Forums

Thailand actively participates in regional cooperation mechanisms in the East Asian Seas and Indian Ocean regions (Annex 10), strengthening transboundary governance and ecosystem-based management. Key platforms include PEMSEA for Integrated Coastal Management (ICM) and Marine Spatial Planning (MSP); ASEAN environmental agreements and working groups; and the Indian Ocean Tuna Commission (IOTC) for tuna fisheries management and IUU fishing control.

Thailand also engages in the ASEAN Agreement on the Conservation of Nature and Natural Resources and the Regional Plan of Action to Combat IUU Fishing (RPOA–IUU), enhancing regional coordination on monitoring, enforcement, and information exchange. Collectively, these regional frameworks reinforce Thailand's commitment to cooperative and transboundary marine governance aligned with global sustainability goals.

6.2.3.3 National Policies and Strategies Relevant to Marine and Coastal Resources

Thailand has established a comprehensive legal and policy framework for the management, conservation, and sustainable use of its marine and coastal resources. These frameworks translate the country's international and regional commitments into national implementation through laws, strategic plans, and coordinated action among multiple government agencies. Together, they provide the legal and institutional foundation for promoting ecosystem-based management, blue economy development, and climate-resilient coastal governance in the South China Sea (SCS) and the Gulf of Thailand.

a) Key Legal Frameworks

Thailand's marine and coastal governance is underpinned by a comprehensive legal framework emphasizing participatory management, biodiversity conservation, and sustainable resource use. Core legislation includes the Promotion of Marine and Coastal Resources Management Act (2015), which establishes national and provincial committees and provides the legal basis for marine and coastal protected areas; the Royal Ordinance on Fisheries (2015), which strengthens sustainable fisheries management and IUU fishing control; and the National Environmental Quality Promotion and Conservation Act (1992, amended 2018), which governs pollution control and Environmental Impact Assessment (EIA).

Additional key laws include the Wildlife Preservation and Protection Act (2019), the National Park Act (2019), the Marine Interest Protection Act (2019), and the Protection and Promotion of Ethnic Groups' Way of Life Act (2025). Two major draft laws—the Climate Change Act and the National Biodiversity Act—are currently under parliamentary consideration and are expected to significantly strengthen Thailand's climate and biodiversity governance once enacted.

These primary laws are supported by ministerial regulations, technical guidelines, and sector-specific legislation that operationalize standards for conservation, pollution control, and participatory management (see Annex 11).

b) National Policy Frameworks and Strategic Plans

Thailand's marine and coastal governance is guided by integrated national strategies aligned with the Sufficiency Economy Philosophy (SEP) and international sustainability commitments (Annex 12). Key frameworks include the 20-Year National Strategy, the 13th National Economic and Social Development Plan, the National Environmental Quality Management Plan, the Climate Change Master Plan and National Adaptation Plan, the National Biodiversity Strategies (NBSAP and Long-term

Biodiversity Strategy), and the National Marine and Coastal Resources Management Policy and Plan. Together, these policies establish the foundation for biodiversity conservation, blue economy development, and climate-resilient coastal governance.

c) Sectoral Policies and Implementation Mechanisms

Sectoral plans translate national strategies into operational action (Annex 13). Key instruments include the Marine Spatial Planning (MSP) Framework (2023), the National and Marine Debris Management Plans (updated 2023), the Biodiversity Master Plan (2023–2027), and the Coastal Erosion Prevention and Management Master Plan (2023–2037). These frameworks support ecosystem-based management, pollution control, habitat restoration, climate adaptation, and cross-sectoral coordination in marine and coastal areas.

6.2.4. Civil Society and Participation

Civil society organizations (CSOs), local communities, the private sector, and academic institutions play an important supporting role in Thailand's marine and coastal governance by contributing to policy implementation, community-based conservation, scientific research, and public awareness. Their engagement strengthens local stewardship, promotes co-management, and enhances governance integration and resilience across coastal areas of the Gulf of Thailand. Participatory and collaborative mechanisms—including community networks, research partnerships, and public–private initiatives—are key channels through which shared responsibility and inclusive governance are advanced at the local level. International engagement mechanisms are addressed separately in Section 6.2.2.2.

6.2.4.1 Key Civil Society and Non-Governmental Organizations (NGOs) in Thailand

Thailand hosts a diverse network of national NGOs, community organizations, and academic institutions active in marine conservation, sustainable livelihoods, and environmental governance, including the Marine Science Association of Thailand, the Seub Nakhasathien Foundation, the Environmental Litigation and Advocacy for the Wants (EnLAW) Foundation, the Sustainable Development Foundation (SDF), and the Raks Thai Foundation. Major universities such as Prince of Songkla University, Mahidol University, Kasetsart University, Ramkhamhaeng University, and Burapha University contribute scientific research, monitoring, and policy-relevant knowledge. Together, these actors form an essential bridge between national policy frameworks and local-level implementation.

6.2.4.2 Legal Basis for Public Participation

Thailand has a strong legal foundation for public participation in marine and coastal resource management. The Promotion of Marine and Coastal Resources Management Act (2015) and the Royal Ordinance on Fisheries (2015) mandate participatory committees, co-management arrangements, and community-based fisheries management. Complementary laws—including the Official Information Act, the National Environmental Quality Act, and decentralization legislation—further guarantee access to information, participation in EIAs, and local government authority in environmental management.

However, empirical studies indicate that the effectiveness of these participatory mechanisms remains uneven. Provincial coordination is often weak, participation can be reactive, and representation of women and small-scale fishers remains limited in some areas (Satumanatpan et al., 2018; 2024).

6.2.4.3 Co-management and Participatory Mechanisms

Thailand has progressively expanded co-management through provincial marine and coastal committees, community-based conservation networks, and participatory monitoring programs. These mechanisms support mangrove conservation, fisheries management, MPAs, and marine biodiversity monitoring. Public–private partnerships and CSR initiatives increasingly supplement government efforts and financing for conservation.

Overall, Thailand has established formal structures and practical mechanisms for participation and co-management. While these frameworks represent a major strength of the governance system, their effectiveness is constrained by coordination gaps, uneven capacity, and inclusiveness challenges. Continued institutional strengthening, capacity building, and long-term financial support are required to ensure that participation translates into sustained conservation and livelihood outcomes.

6.2.5 Governance performance and effectiveness

Over the past 15 years, Thailand has established a relatively strong legal, policy, and institutional foundation for marine and coastal governance, with a clear shift from fragmented, sector-based management toward more integrated approaches (Satumanatpan et al., 2018). The Promotion of Marine and Coastal Resources Management Act (2015) marked a major institutional advance by creating formal national and provincial committees for coordination, planning, and annual reporting by the Department of Marine and Coastal Resources (DMCR).

Despite this progress, several structural weaknesses persist. Inter-ministerial coordination at the national level remains largely procedural, with overlapping mandates and regulatory inefficiencies continuing to constrain implementation (Satumanatpan, NEA 2025). While ecosystem-based management (EBM), climate adaptation, and disaster risk reduction are increasingly reflected in policy frameworks, their effectiveness depends on data quality, institutional capacity, and the extent to which monitoring results inform adaptive management.

Monitoring, Evaluation, and Policy Cycle

DMCR conducts long-term monitoring of coral reefs, mangroves, and seagrass, generating valuable biophysical time-series data. However, current indicators focus mainly on habitat condition (e.g., live coral cover) and remain weak in assessing ecosystem services and socio-economic outcomes such as fisheries productivity, shoreline protection, tourism, and community well-being (National Trialogue Workshop, 2025). Stronger integration of ecological, economic, and social indicators is needed to support adaptive governance.

Participation, Coordination, and Stakeholder Engagement

Thailand’s legal framework formally enables stakeholder participation through the Marine and Coastal Resources Management Act (2015) and the Royal Ordinance on Fisheries (2015). In practice, however, participatory mechanisms remain uneven. Provincial coastal committees face weak sectoral integration, infrequent meetings, and limited data availability (Satumanatpan et al., 2018). Further constraints include reactive committee agendas, limited women’s representation, and perceived imbalances in decision-making authority (Satumanatpan et al., 2024).

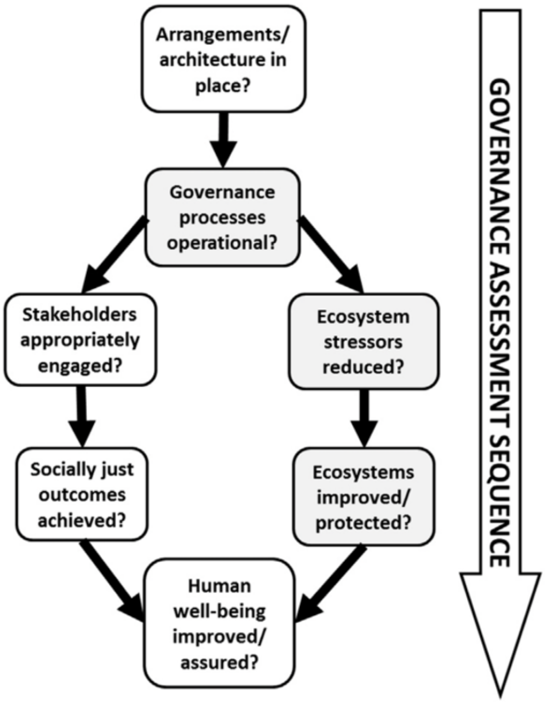
Governance Principles

Although this assessment does not directly evaluate transparency, accountability, and equity, these principles are supported by Thailand’s broader legal framework, including the Official Information Act (1997), the Civil Service Act (2008), the 2017 Constitution, and the Gender Equality Act (2015). Together, these laws establish an enabling environment for participatory and accountable governance, although enforcement and practical application remain uneven.

Overall, Thailand’s marine and coastal governance shows significant institutional progress, but its effectiveness is constrained by coordination gaps, limited socio-economic monitoring, and uneven stakeholder inclusion. Strengthening adaptive monitoring systems, inclusive participation, and inter-agency coordination remains essential for improving long-term governance performance.

6.3 Discussion and Conclusions

6.3.1 Risk Assessment: Current Governance Capacity



National indicators suggest that Thailand's overall governance capacity for coastal and marine management is moderate but uneven. Under the Environmental Performance Index (EPI 2024), Thailand ranks 90th globally, with improvements in climate change performance (+12.5) and ecosystem vitality (+1.9), but declining trends in biodiversity and habitat (–0.7) and fisheries (–1.9), alongside persistently weak water resource management. These patterns reflect continuing stress on coastal ecosystems.

World Bank Worldwide Governance Indicators place Thailand in the medium tier for government effectiveness and regulatory quality, with a declining trend in regulatory performance and low control of corruption (World Bank, 2025). These national-level governance constraints influence provincial capacity, particularly consistency in policy implementation, enforcement, and multi-agency coordination.

At the provincial level, governance performance varies widely. Coastal committee studies reveal weak sectoral integration, infrequent meetings, and limited stakeholder engagement (Satumanatpan et al., 2018). Further constraints include reactive committee agendas, low women's representation, and imbalances in committee composition affecting small-scale fishers (Satumanatpan et al., 2024). These shortcomings undermine social equity, inclusion, and adaptive capacity.

Overall, Thailand exhibits moderate national governance capacity, but uneven provincial implementation remains a key risk to effective ecosystem protection and human well-being.

TWAP Governance Architecture Self-Assessment (Fanning et al., 2017) shows:

- Completeness = 50 (basic institutional and legal structures exist),
- Integration = 0.1 (very weak cross-sectoral and multi-level coordination),
- Engagement = 70 (relatively strong stakeholder participation).

This indicates that while institutions and participation mechanisms are in place, fragmented integration remains the principal structural weakness constraining adaptive, ecosystem-based, and transboundary governance in the South China Sea and Gulf of Thailand.

6.3.2 Current governance capacity to respond to climate and major environmental changes, as well as population growth and demand

Thailand shows moderate capacity to respond to climate and environmental change, supported by national frameworks but constrained by fragmented coordination and uneven enforcement. Core agencies (DMCR, DCCE, DOF) possess growing technical capacity, yet the absence of an enacted Climate Change Act weakens legal coherence.

Climate and coastal monitoring systems exist but remain poorly integrated, limiting their effectiveness for planning. Provincial governments face persistent staffing and budget constraints, while rapid urbanization, coastal development, and resource demand outpace institutional capacity. These conditions underscore the need for stronger coordination, clearer legal mandates, and adaptive governance mechanisms.

6.3.3 Strategies to enhance government responses to climate change and achieve sustainability of the coastal and marine environments

Thailand’s climate response is guided by the Climate Change Master Plan (2015–2050) and the National Adaptation Plan, which emphasize resilience and ecosystem-based adaptation in coastal and marine areas. The draft Climate Change Act, currently under parliamentary consideration, is expected to strengthen the legal foundation for coordinated, cross-sectoral climate governance and long-term sustainability.

6.3.4 Recommended priority actions including regional cooperation

Based on identified risks and governance gaps, the following priority actions are recommended:

1. Improve cross-sectoral and multi-level coordination.

Enhance institutional linkages among DMCR, DCCE, DOF, ONEP, DNP, the Marine Department, and provincial authorities to ensure coherent implementation of national policies. Strengthening the operational effectiveness of coastal provincial committees—including regular meetings, clear agendas, and technical support—will be essential for more consistent provincial-level implementation.

2. Enhance legal coherence for climate and environmental governance.

Finalizing and enacting the draft *Climate Change Act* should be prioritized to provide a binding legal framework for climate action. Aligning climate-related frameworks with the Marine and Coastal Resources Management Act (2015), National Adaptation Plan, and marine spatial planning processes will support integrated land–sea management and long-term resilience planning.

3. Strengthen provincial implementation capacity.

Increase technical staffing, financial resources, and targeted training for provincial and local authorities, particularly in areas facing high exposure to coastal erosion, flooding, pollution, and fisheries pressures. Integrating climate risk assessments into local planning and enhancing monitoring capacity will improve adaptive responses.

4. Promote inclusive and equitable stakeholder participation.

Enhance mechanisms for the meaningful involvement of small-scale fishers, women, and community-based organizations in provincial decision-making processes. Expanding representation and improving transparency can strengthen governance legitimacy and support socially just outcomes.

5. Accelerate ecosystem protection and climate-resilient management.

Scale up mangrove, seagrass, and coral reef restoration; strengthen pollution control; and expand protected area management using nature-based and ecosystem-based approaches. Improving enforcement and compliance mechanisms will be critical for reducing ecosystem stresses.

6. Strengthen data integration and science–policy linkages.

Develop interoperable data systems among national agencies and increase the use of shared datasets for planning and decision-making. Enhancing collaboration with research institutions will support monitoring of environmental change, fisheries productivity, and climate impacts.

7. Enhance regional cooperation in the South China Sea.

Deepen engagement through ASEAN, COBSEA, PEMSEA, SEAFDEC, and UNEP/GEF platforms to improve coordinated monitoring of marine pollution, management of shared fish stocks, exchange of adaptation practices, and development of regional early warning systems. Establishing regional protocols for data-sharing and transboundary ecosystem management should be prioritized.

8. Mobilize sustainable and long-term financing.

Strengthen domestic budgeting for climate and coastal management and explore regional and international financing mechanisms, including climate funds, blue carbon financing, and blended finance instruments to support implementation and monitoring at national and provincial levels.

6.4 Methodology and analysis

This governance assessment was conducted using a desk-based analytical approach combined with comparative indicator-based evaluation, aligned with the Transboundary Water Assessment Programme (TWAP) Governance Architecture

Assessment Framework (Fanning et al., 2017). The analysis focuses on four core governance components: economic arrangements, institutional setting, legal and policy frameworks, and civil society and stakeholder engagement.

Data were compiled through a desk-based review of official government documents, national strategies and legislation, budget and investment statistics, international reporting instruments, and peer-reviewed literature. Key national data sources included the Department of Marine and Coastal Resources (DMCR), Office of the National Economic and Social Development Council (NESDC), Bureau of the Budget, Board of Investment (BOI), and relevant ministry reports. International governance indicators, including the World Bank Worldwide Governance Indicators and the Environmental Performance Index (EPI), were used to contextualize national governance performance.

To assess transboundary governance architecture, Thailand's national governance system was evaluated using the TWAP Governance Architecture Assessment Framework, based on three dimensions: completeness, integration, and engagement. A structured self-assessment was conducted using expert judgment informed by institutional mandates, legal coverage, participation mechanisms, and inter-agency coordination arrangements. Supporting quantitative and qualitative evidence from previous regional studies and project reports was used to validate the assessment results.

The analysis integrates findings across governance components to identify systemic strengths, gaps, risks, and enabling conditions relevant to transboundary ecosystem management. Particular attention is given to stakeholder participation, inter-sectoral coordination, financing capacity, and implementation effectiveness at both national and provincial levels. All detailed datasets, methodological tools, and supplementary materials used in this assessment are provided in the Annexes to support transparency and replicability.

Glossary

DMCR	Department of Marine and Coastal Resources
DCCE	Department of Climate Change and Environment, the primary A government agency in Thailand responsible for climate policy and environmental management.
DOF	Department of Fisheries
GDP	Gross Domestic Product: the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period.
GPP	Gross Provincial Product; the total economic value of all final goods and services produced within a specific province during a given period.
TDA	Transboundary Diagnostic Analysis
TWAP	Transboundary Water Assessment Programme
More xxxx	

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Author contributions

Suvaluck Satumanatpan: Methodology, Validation, Investigation, Visualization, Writing-Original draft, Writing-Review & Editing, Megan Kinght: Methodology, Writing-Review & Editing

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VII. Conclusion

7.1 Meeting the TDA objectives

The 2025 National Transboundary Diagnostic Analysis has successfully met its primary objectives as set out in the inception phase. It has established a scientifically grounded 2024–2025 baseline for fisheries stock health, pollution loads, and ecosystem coverage, effectively updating the data from the previous 2000 assessment. The analysis has verified the causal chains linking land-based activities—specifically industrialization in the Eastern Economic Corridor (EEC) and intensive agriculture—to the degradation of marine resources in the Gulf of Thailand. Furthermore, it has identified the "implementation gap" between legislation and enforcement as the critical governance weakness.

Crucially, the validation of these findings was solidified during the TDA Review Meeting convened by the Department of Marine and Coastal Resources (DMCR) on **November 17, 2025**. The objective of this meeting was to collaboratively review and discuss the results of the 2025 Transboundary Diagnostic Analysis and the draft preliminary report. This updated report underscores that it will play a critical role in supporting the formulation of the next phase of the SAP, ensuring that future projects are actionable and continuous. Additionally, the analysis results are intended to be applied to improve national environmental databases and development processes, ensuring that Thailand's marine management is data-driven and aligned with regional goals .

7.2 Key conclusions and crosscutting interactions

The assessment reveals a complex web of interactions where **climate change acts as a threat multiplier** for existing local stressors:

- **Climate-Pollution Nexus:** Eutrophic waters in the Upper Gulf reduce the thermal tolerance of coral reefs, making them more susceptible to mass bleaching during marine heatwaves. Pollution control is therefore a key climate adaptation strategy.
- **Socio-Economic Vulnerability:** There is a stark divergence in resilience. The wealthy industrial East faces financial risks to infrastructure, while the agrarian South faces livelihood risks due to resource depletion and poverty.
- **Land-Sea Integration**: The analysis underscores the critical need for Land-Sea Integration. The "Land-Sea Disconnect" remains a primary driver of degradation, where terrestrial activities (nutrient runoff, sediment loading) undermine marine ecosystem health. Future management must bridge this gap by treating watersheds and coastal zones as a single continuum.
- **Fisheries Threats and Management:**
    - **Ecosystem Approach**: There is an urgent need to shift towards an Ecosystem Approach to Fisheries Management (EAFM), particularly in vulnerable areas where single-species management has failed to prevent degradation.
    - **Gear Selectivity and Catch Efficiency:** The prevalence of non-selective fishing gears (e.g., trawlers with high catch efficiency but poor

selectivity) continues to capture high volumes of juvenile fish and "trash fish" compared to selective gears. This unsustainable Fishing Effort directly impacts stock recruitment and ecosystem balance.
    - **Governance and Legal Contradictions:** A critical governance finding is the practical contradiction between legal sections regarding by-catch reduction. Specifically, tensions exist between Section 57 (which prohibits the catch of juvenile aquatic animals below a prescribed size) and Section 69 (which regulates fishing gear specifications, such as mesh sizes). In practice, fishers operating "legal" gear under Section 69 often still catch undersized fish prohibited by Section 57, creating an enforcement loophole. The TDA recommends resolving this legal ambiguity to effectively reduce by-catch.
- **Transboundary Species Management**: The report highlights the necessity of regional cooperation for Transboundary Species. Joint management initiatives must be strengthened, building on frameworks like the GOT Fish Project led by SEAFDEC, to ensure harmonized regulations across the Gulf of Thailand.

Note on Methodological Constraints: It is important to note that **Ocean Accounts** were not utilized in this assessment. This decision was due to current limitations in isolating marine-specific data within national statistics and the necessity to maintain consistency with the project's original indicator framework to ensure comparability with historical data.

7.3 Patterns of risk among spatial units of analyses and at country scale

Risk is not evenly distributed across Thailand's maritime domain. The TDA identifies three distinct risk typologies:

1) **The Industrial Hotspot (Upper Gulf & EEC):** Characterized by **High Environmental Risk** (hypoxia, hazardous waste, microplastics) but **High Adaptive Capacity** (wealthy provinces). The priority here is regulation and technological mitigation.
2) **The Livelihood Trap (Lower Gulf/Deep South):** Characterized by **Moderate Environmental Risk** but **High Social Vulnerability** (poverty >20%). Climate shocks here directly translate to human suffering due to high dependence on nature.
3) **The Ecological Refugia (Offshore Islands):** Sites like Koh Losin and the Chumphon Pinnacles represent **Low Risk/High Value** assets. They act as the "biological insurance" for the Gulf and require strict protection from physical damage to maintain larval connectivity.

7.4 Target audience

This report targets five distinct groups to drive change:

- **National Policymakers (NESDC, MONRE):** To integrate "Blue Carbon" and marine spatial planning into the National Economic and Social Development Plan.
- **Provincial Administrations (PAOs):** Specifically in the EEC and Southern

provinces, to guide zoning and waste management investments.

- **Private Sector Investors:** To highlight the financial risks of operating in degraded ecosystems and the opportunities in "Nature-based Solutions" (e.g., mangrove carbon credits).
- **Local Actors and Communities:** To align policy with local realities, frameworks such as the Fisheries Action Plan must be adapted to the specific context of small-scale (artisanal) fisheries. Recognizing that regulations designed for large commercial fleets are often inapplicable at the community level, this approach prioritizes differentiated management measures that secure local livelihoods while ensuring long-term resource sustainability.
- **International Partners (GEF, UNEP):** To demonstrate Thailand's readiness for regional cooperation on transboundary issues like marine plastics and migratory fish stocks.

7.5 Future indicator-based environmental assessments

Moving forward, Thailand must evolve its assessment framework from "Status Monitoring" to "Resilience Monitoring":

- **Process Indicators:** Shift from measuring just "forest area" to measuring "carbon sequestration rates" and "seedling survival".
- **Integrated Monitoring:** Collate water quality data (PCD) with coral health data (DMCR) in real-time to predict and mitigate bleaching events.
- **Socio-Economic Metrics:** Regularly track the "Ocean Health Index" and "Coastal Livelihood Vulnerability" to ensure that governance interventions are socially equitable.
- **Ocean Literacy and Blue Curriculum:** Future assessments and development strategies should consider **Ocean Literacy** and the **Blue Curriculum** as fundamental drivers for socio-economic development. Aligning national education with the **UNESCO/WESTPAC** framework will build a citizenry capable of understanding and protecting marine resources, ensuring the long-term success of technical interventions.

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Annex Volume

Annex I: Socioeconomics and Climate-Related Threats

Annex 2.1 Methodology and calculation process of the Composite Risk Index (CRI)

The Composite Risk Index (CRI) was developed as a quantitative tool to assess and rank risk levels across 17 provinces along the Gulf of Thailand. By analyzing key socioeconomic trends, the index identifies areas most affected by development pressures. The conceptual design operates on the principle that Risk arises from the interaction between Pressure (threats from human activity) and Vulnerability (social sensitivity). This approach aligns with the internationally recognized DPSIR framework (Driving forces - Pressures - State - Impacts - Responses), which maps the complex interactions between society and the environment (EEA, 1999; Kristensen, 2004). The calculation process follows a five-step methodology, detailed below:

Step 1: Data acquisition and indicator selection

The analysis utilizes secondary data covering a two-decade period (2000–2020) to capture long-term structural changes. The CRI comprises two primary indices, Pressure Index (PI) and Vulnerability Index (VI), which are derived from the following raw indicators:

1. Pressure Index (PI) indicators:
    - Population count: Total registered population (Persons) in years 2000 and 2020.
    - Household count: Total number of registered households (Units) in years 2000 and 2020.
    - Population density: Population per square kilometer (Persons/km^2) in the year 2020.
    - Gross Provincial Product (GPP): Economic output based on Chain Volume Measures (Reference year = 2002) in years 2000 and 2020.
2. Vulnerability Index (VI) indicators:
    - Poverty headcount: Number of people living below the poverty line (Persons) in years 2000 and 2020.

- Gender ratio imbalance: The deviation of the male-to-female ratio from the standard 1:1 balance in the years 2020.

The Gender Ratio Imbalance index was calculated using 2020 population data. This indicator quantifies the extent to which a province's population deviates from a balanced male-to-female ratio (1:1). A higher deviation indicates a skewed demographic structure, which can imply specific social vulnerabilities such as labor migration effects or gender-specific dependency burdens.

Step 2: Calculation of temporal change (CAGR)

To account for year-to-year fluctuations inherent in raw data, the analysis utilizes the Compound Annual Growth Rate (CAGR) instead of a simple percentage change. This approach is necessary to accurately measure structural trends in pressure and vulnerability over the 20-year assessment period. Accordingly, the CAGR is calculated for all indicators measuring temporal change, including population, households, GPP, poverty, and gender imbalance. This method provides a standardized and smoothed annual growth rate, effectively dampening the influence of short-term volatility. This step yields a raw growth rate (e.g., 2.5% or 0.025) for each indicator per province.

Formula: $CAGR = \left(\frac{Value_{2020}}{Value_{2000}}\right)^{\frac{1}{n}} - 1$

Where:

$Value_{2020}$ = Value of the indicator in the ending year.

$Value_{2000}$ = Value of the indicator in the beginning year.

n = Number of years (20 years).

Step 3: Data Normalization

Given that the raw data and derived CAGR values utilize heterogeneous units (e.g., population counts, monetary values, and percentages), direct mathematical aggregation is not feasible. To address this, normalization is required to transform all indicators onto a common, dimensionless scale ranging from 0 to 1. Consequently, Min-Max Normalization is applied to all metrics, including both the temporal change values from Step 2 and the static density data, to ensure comparability and facilitate accurate aggregation. For indicators where a higher value is positive (e.g., poverty reduction), the formula is inverted ($1 - I_x$) so that in the final index, a higher score consistently indicates a negative outcome (Higher risk). This step produces the specific **I** values (e.g., I_{Pop}, I_{GPP}, I_{Poor}) ready for aggregation.

Formula: $I_x = \frac{X_i - X_{Min}}{X_{max} - X_{min}}$

Where:

I_x = The normalized score (0–1) for province i.

X_i = The CAGR value for province i.

X_{min} = The minimum of CAGR value among all 17 provinces.

X_{max} = The maximum of CAGR value among all 17 provinces.

Step 4: Aggregation of Sub-Indices

Once normalized, the indicators are grouped into Pillars and aggregated into the two main indices using simple averaging (Equal weighting).

4.1 The Pressure Index (PI)

The PI is the average of three pillars:

- Pillar 1: Population dynamics: Measures the rate of population expansion.

$$Score_{P1} = \frac{I_{Pop} + I_{HH}}{2}$$

Where I_{Pop} is normalized population growth and I_{HH} is normalized household growth

- Pillar 2: Population Density: Measures current crowding pressure.

$$Score_{P2} = I_{PopDense2020}$$

Note: Only 2020 data is used to avoid statistical redundancy with Pillar 1

- Pillar 3: Economic Pressure: Measures the scale of economic activity.

$$Score_{P3} = I_{GPP}$$

Final PI Calculation:

$$PI = (0.333xScore_{P1}) + (0.333xScore_{P2}) + (0.333xScore_{P3})$$

4.2 The Vulnerability Index (VI)

The VI is the average of two indicators representing social sensitivity:

- Indicator 1 (I_{Poor}): Normalized change in poverty headcount.
- Indicator 2 ($I_{Imbalance}$): Normalized change in gender ratio imbalance.

Final VI Calculation: $VI = (0.5\ x\ I_{Poor}) + (0.5\ x\ I_{Imbalance})$

Step 5: Computation of the Composite Risk Index (CRI)

The final assessment is presented in two formats to support differentiated policy decision-making.

Format 1: Risk intensity (CRI_Unweighted)

This score measures the concentration of risk. It highlights areas where socioeconomic pressures are most intense relative to the local context, regardless of the province's physical size.

Formula:

$$CRI_{Unweighted} = (0.5xPI) + (0.5xVI)$$

Format 2: Risk magnitude (CRI_Final)

This score incorporates the physical scale of the province. It serves as a proxy for the "management workload" (e.g., land area).

Formula:

$$CRI_{Final} = CRI_{Unweighted}\ x\ Area\ weight$$

Where:

$$Area\ weight = \frac{Area_{Province}}{\sum Area_{All17Provinces}}$$

Risk Categorization

By analyzing both Format 1 (Intensity) and Format 2 (Magnitude), provinces are classified into three actionable groups:

1. Pure Intensity Risk: High concentration of pressure.
2. Pure Magnitude Risk: Large scale of vulnerable resources.
3. Hybrid Risk: High scores in both intensity and magnitude.

Annex 2.2 Land area and national share of coastal provinces along the Gulf of Thailand (2020)

Provinces	Area (km^2)	National share (%)
Rayong	3,552.0	0.69
Chanthaburi	6,338.0	1.24
Trat	2,819.0	0.55
Samut Prakan	1,004.1	0.20
Chon Buri	4,363.0	0.85
Chachoengsao	5,351.0	1.04
Samut Sakhon	872.3	0.17
Samut Songkhram	416.7	0.08
Phetchaburi	6,225.1	1.21
Prachuap Khiri Khan	6,367.6	1.24
Nakhon Si Thammarat	9,942.5	1.94
Surat-Thani	12,891.5	2.51
Chumphon	6,009.0	1.17
Songkhla	7,393.9	1.44
Pattani	1,940.4	0.38
Narathiwat	4,475.4	0.87
Bangkok	1,569	0.31

Source: Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Annex 2.3 Population and household number in Thailand's coastal provinces along the Gulf of Thailand (2000, 2005, 2010, 2020)

Provinces	Year	Male	Female	Household
Rayong	2000	262,213	261,305	190,527
	2005	276,917	282,217	250,725
	2010	309,014	317,388	323,056
	2020	364,200	377,324	506,761
Chanthaburi	2000	246,182	247,252	149,732
	2005	246,468	251,691	174,933
	2010	253,618	260,998	197,815
	2020	262,027	273,532	243,727
Trat	2000	113,184	110,740	70,386
	2005	110,281	108,854	81,066
	2010	110,429	110,492	90,876
	2020	113,131	115,405	108,270
Samut Prakan	2000	485,562	510,276	363,684
	2005	523,247	554,276	425,081
	2010	572,079	613,101	514,174
	2020	644,516	706,963	711,804
Chon Buri	2000	542,913	535,605	426,953
	2005	577,878	594,553	551,722
	2010	646,266	670,027	706,277
	2020	763,983	802,902	1,070,209
Chachoengsao	2000	315,920	323,831	175,139
	2005	318,037	329,573	203,314
	2010	330,716	343,217	235,328
	2020	353,442	367,276	313,586
Samut Sakhon	2000	210,494	218,320	161,658
	2005	219,731	232,286	193,350
	2010	237,906	253,981	233,668
	2020	282,723	303,476	296,825
Samut Songkhram	2000	99,493	105,502	45,642
	2005	93,893	101,175	51,964
	2010	93,405	100,652	59,695
	2020	91,825	100,227	72,732
Phetchaburi	2000	222,772	234,121	130,928
	2005	219,885	234,097	149,442
	2010	224,860	239,173	167,643

	2020	232,915	249,278	220,362
Prachuap Khiri Khan	2000	243,378	235,566	138,021
	2005	245,569	241,227	165,927
	2010	255,584	253,550	202,731
	2020	272,849	277,829	271,890
Nakhon Si Thammarat	2000	759,738	764,820	368,401
	2005	747,639	756,781	422,166
	2010	755,601	766,960	476,439
	2020	765,370	785,351	581,948
Surat-Thani	2000	446,265	447,269	255,988
	2005	470,126	477,223	324,617
	2010	494,825	505,558	394,041
	2020	525,716	542,010	512,366
Chumphon	2000	232,866	230,528	139,964
	2005	237,689	238,074	169,200
	2010	243,594	246,370	193,848
	2020	251,370	257,838	240,248
Songkhla	2000	607,720	624,880	311,407
	2005	637,355	665,067	373,725
	2010	662,475	694,548	434,137
	2020	696,349	732,260	553,597
Pattani	2000	301,929	310,198	123,863
	2005	313,132	321,242	141,511
	2010	323,573	331,686	157,145
	2020	358,611	367,404	195,224
Narathiwat	2000	338,247	340,888	139,040
	2005	347,087	353,438	160,062
	2010	364,898	372,264	177,735
	2020	397,700	406,729	219,403
Bangkok	2000	2,761,012	2,919,368	1,900,235
	2005	2,705,954	2,953,000	2,091,558
	2010	2,709,568	2,991,826	2,400,540
	2020	2,625,938	2,962,284	3,103,483
Nation	2000	30,725,016	31,153,730	16,516,322
	2005	30,818,621	31,599,421	19,016,784
	2010	31,451,801	32,426,466	21,681,635
	2020	32,375,532	33,811,195	27,224,743

Source: Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php

(accessed 19 April 2025)

Annex 2.4 Annual population changes (%) by coastal provinces along the Gulf of Thailand (2000-2020)

Provinces	2000-2005	2005-2010	2010-2015	2015-2020
Rayong	1.13	2.01	1.67	1.27
Chanthaburi	0.16	0.55	0.53	0.14
Trat	-0.36	0.14	0.64	-0.07
Samut Prakan	1.37	1.67	1.32	0.94
Chon Buri	1.45	2.05	1.76	1.28
Chachoengsao	0.20	0.68	0.67	0.47
Samut Sakhon	0.90	1.47	1.82	1.24
Samut Songkhram	-0.81	-0.09	0.03	-0.20
Phetchaburi	-0.11	0.37	0.52	0.13
Prachuap Khiri Khan	0.27	0.76	0.84	0.50
Nakhon Si Thammarat	-0.22	0.20	0.33	-0.02
Surat-Thani	1.00	0.93	0.77	0.33
Chumphon	0.44	0.50	0.54	0.11
Songkhla	0.94	0.70	0.66	0.21
Pattani	0.61	0.55	0.99	0.77
Narathiwat	0.52	0.87	1.04	0.45
Bangkok	-0.06	0.12	-0.01	-0.32

Source: Author’s calculation based on data from Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Annex 2.5 Provincial share of coastal population (%) along the Gulf of Thailand (2000, 2005, 2010, 2020)

Provinces	2000	2005	2010	2020
Rayong	0.8	0.9	1.0	1.1
Chanthaburi	0.8	0.8	0.8	0.8
Trat	0.4	0.4	0.3	0.3
Samut Prakan	1.6	1.7	1.9	2.0
Chon Buri	1.7	1.9	2.1	2.4
Chachoengsao	1.0	1.0	1.1	1.1
Samut Sakhon	0.7	0.7	0.8	0.9
Samut Songkhram	0.3	0.3	0.3	0.3
Phetchaburi	0.7	0.7	0.7	0.7
Prachuap Khiri Khan	0.8	0.8	0.8	0.8
Nakhon Si Thammarat	2.5	2.4	2.4	2.3
Surat-Thani	1.4	1.5	1.6	1.6
Chumphon	0.7	0.8	0.8	0.8
Songkhla	2.0	2.1	2.1	2.2
Pattani	1.0	1.0	1.0	1.1
Narathiwat	1.1	1.1	1.2	1.2
Bangkok	9.2	9.1	8.9	8.4

Source: Author's calculation based on data from Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Annex 2.6 Population density of Thailand and coastal provinces (person/km^2) along the Gulf of Thailand (2000, 2005, 2010, 2020)

Provinces	2000	2005	2010	2020
Rayong	147	157	176	209
Chanthaburi	78	79	81	84
Trat	79	78	78	81
Samut Prakan	992	1,073	1,180	1,346
Chon Buri	247	269	302	359
Chachoengsao	120	121	126	135
Samut Sakhon	492	518	564	672
Samut Songkhram	492	468	466	461
Phetchaburi	73	73	75	77
Prachuap Khiri Khan	75	76	80	86
Nakhon Si Thammarat	153	151	153	156
Surat-Thani	69	73	78	83
Chumphon	77	79	82	85
Songkhla	167	176	184	193
Pattani	315	327	338	374
Narathiwat	152	157	165	180
Bangkok	3,620	3,607	3,634	3,562
Thailand	121	122	124	129

Source: Author's calculation based on data from Department of Provincial Administration. 2025. Official statistics registration systems. https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/home.php (accessed 19 April 2025)

Annex 2.7 Percentage of population at mid-year residing in urban areas of Thailand (1950-2050)

Year	% population residing in urban areas
1950	16.5
1951	16.8
1952	17.1
1953	17.4
1954	17.7
1955	18.0
1956	18.4
1957	18.7
1958	19.0
1959	19.4
1960	19.7
1961	19.8
1962	19.9
1963	20.0
1964	20.1
1965	20.2
1966	20.3
1967	20.4
1968	20.6
1969	20.7
1970	20.9
1971	21.4
1972	22.0
1973	22.6
1974	23.2
1975	23.8
1976	24.4
1977	25.0
1978	25.6
1979	26.2
1980	26.8
1981	27.0
1982	27.3
1983	27.6
1984	27.8
1985	28.1

Annex 2.7 Cont.

Year	% population residing in urban areas
1986	28.4
1987	28.6
1988	28.9
1989	29.2
1990	29.4
1991	29.6
1992	29.8
1993	29.9
1994	30.1
1995	30.3
1996	30.4
1997	30.6
1998	30.8
1999	31.0
2000	31.4
2001	32.5
2002	33.7
2003	34.9
2004	36.2
2005	37.4
2006	38.7
2007	40.0
2008	41.2
2009	42.5
2010	43.9
2011	44.7
2012	45.4
2013	46.2
2014	46.9
2015	47.7
2016	48.4
2017	49.2
2018	49.9
2019	50.7
2020	51.4
2021	52.2

Annex 2.7 Cont.

Year	% population residing in urban areas
2022	52.9
2023	53.6
2024	54.3
2025	55.0
2026	55.7
2027	56.4
2028	57.1
2029	57.8
2030	58.4
2031	59.1
2032	59.7
2033	60.3
2034	61.0
2035	61.6
2036	62.2
2037	62.8
2038	63.3
2039	63.9
2040	64.4
2041	65.0
2042	65.5
2043	66.0
2044	66.5
2045	67.0
2046	67.5
2047	68.0
2048	68.5
2049	69.0
2050	69.5

Source: United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision, Online Edition.

Annex 2.8 Loss of natural and semi-natural vegetated land in Thailand (2005, 2010, 2015, 2020, 2022)

Year	%
2005	1.26
2010	1.62
2015	1.79
2020	2.05
2022	2.13

Source: OECD Data Explorer. 2025. Land cover and land change. https://data-explorer.oecd.org/ (accessed 25 May 2025)

Annex 2.9 Poor people (x1,000 people) in coastal provinces along the Gulf of Thailand (2000, 2006, 2010, 2020)

Provinces	2000	2006	2010	2020
Rayong	127.9	46.4	29.4	4.9
Chanthaburi	213.1	50.3	50.3	36.7
Trat	106.9	62.8	65.9	30.6
Samut Prakan	59.0	52.9	27.7	4.4
Chon Buri	174.1	35.9	32.1	0.7
Chachoengsao	144.0	94.9	90.0	12.0
Samut Sakhon	129.9	112.0	79.6	13.1
Samut Songkhram	28.1	49.7	21.4	11.6
Phetchaburi	182.5	65.6	57.6	17.2
Prachuap Khiri Khan	212.5	78.7	120.7	18.2
Nakhon Si Thammarat	817.5	261.6	154.7	146.9
Surat-Thani	188.2	89.2	38.7	34.5
Chumphon	119.8	67.3	17.0	31.9
Songkhla	416.4	145.6	121.5	100.4
Pattani	367.8	261.8	330.5	285.4
Narathiwat	485.5	440.9	236.1	182.2
Bangkok	372.6	214.7	186.7	44.1
Thailand	25,778.0	13,779.7	10,800.7	4,748.2

Source: Office of the National Economic and Social Development Council. 2025. Household Socio-Economic Survey by the National Statistical Office; compiled by the Division of Social Data and Indicators Development, NESDC. https://www.nesdc.go.th/main.php?filename=social (accessed 22 April 2025)

Annex 2.10 HDI of Thailand (1990-2023)

Year	HDI
1990	0.584
2000	0.657
2010	0.742
2015	0.788
2020	0.798
2021	0.800
2022	0.792
2023	0.798

Source: UNDP. 2025. Human Development Reports. https://hdr.undp.org/data-center/documentation-and-downloads (accessed 22 April 2025)

Annex 2.11 IHDI of Thailand (2012-2023)

Year	IHDI
2012	0.622
2013	0.627
2014	0.656
2015	0.661
2016	0.662
2017	0.665
2018	0.667
2019	0.676
2020	0.675
2021	0.676
2022	0.67
2023	0.677

Source: UNDP. 2025. Human Development Reports. https://hdr.undp.org/data-center/documentation-and-downloads (accessed 22 April 2025)

Annex 2.12 GPP per capita (USD) by sector of coastal provinces along the Gulf of Thailand (1995-2018)

Year	Rayong				Chanthaburi			
	Agriculture	**Industrial**	**Services**	**GPP**	**Agriculture**	**Industrial**	**Services**	**GPP**
1995	571.76	6,237.37	1,704.53	8,565.61	1,035.54	113.15	771.15	1,919.26
1996	551.84	7,059.34	1,843.23	9,489.23	1,068.05	126.47	819.93	2,017.14
1997	512.27	8,119.16	1,962.69	10,599.02	1,051.09	120.03	783.60	1,953.91
1998	473.51	7,712.33	1,742.08	9,919.21	845.83	101.91	712.78	1,666.29
1999	504.81	7,540.67	1,539.68	9,581.59	881.88	96.28	737.63	1,720.20
2000	537.26	8,593.78	1,695.34	10,815.23	983.47	137.91	771.95	1,895.08
2001	501.66	8,335.72	1,581.62	10,408.68	1,028.86	133.77	750.64	1,909.96
2002	503.02	9,415.65	1,625.42	11,544.08	1,043.39	127.41	795.58	1,966.37
2003	513.86	9,454.66	1,634.51	11,603.03	1,037.72	153.41	813.36	2,004.49
2004	466.78	9,730.23	1,777.42	11,970.17	971.01	160.17	827.64	1,956.69
2005	421.36	10,017.73	1,887.31	12,315.51	921.28	170.80	873.97	1,957.25
2006	425.12	10,143.08	1,872.86	12,433.82	969.86	166.67	913.04	2,042.14
2007	444.16	10,228.89	1,987.87	12,636.24	944.53	200.99	978.51	2,100.34
2008	459.04	9,596.48	1,945.03	11,959.96	1,082.77	214.35	911.36	2,230.33
2009	414.50	9,612.94	1,821.83	11,838.03	963.28	225.28	974.62	2,151.13
2010	415.27	10,332.44	2,004.95	12,733.69	1,134.42	250.32	1,003.79	2,416.05
2011	430.32	9,673.49	1,995.40	12,070.05	1,223.45	223.43	1,074.80	2,561.12
2012	369.74	10,109.48	1,920.73	12,381.46	1,568.04	296.61	1,340.51	3,263.33
2013	332.40	10,275.92	1,971.75	12,555.64	1,530.20	262.21	1,242.34	3,109.22
2014	323.37	9,829.64	2,007.33	12,110.75	1,513.40	251.92	1,227.58	3,068.14
2015	269.19	10,011.72	2,083.05	12,310.96	1,380.58	249.92	1,315.94	2,980.80
201	261.17	10,117.	2,127.	12,449.	1,189.46	259.83	1,375.	2,803.

6		23	34	50			39	07
2017	295.08	10,274.46	2,215.68	12,724.79	1,412.78	303.41	1,518.39	3,232.80
2018	257.97	9,900.57	2,293.56	12,370.11	1,143.64	274.20	1,449.79	2,807.59

Source: Office of the National Economic and Social Development Council. 2025. GDP. https://www.nesdc.go.th/nesdb_en/more_news.php?cid=156&filename=index (Accessed 21 Apr 2025)

Annex 2.12 Cont.

Year	Trat				Samut Prakan			
	Agriculture	**Industrial**	**Services**	**GPP**	**Agriculture**	**Industrial**	**Services**	**GPP**
1995	1,130.38	100.06	831.18	2,042.76	226.86	3,458.42	2,357.10	6,043.41
1996	1,114.20	107.95	815.73	2,019.92	225.90	3,501.69	2,363.08	6,092.64
1997	1,087.69	108.61	855.92	2,039.75	237.68	3,316.36	2,257.88	5,813.17
1998	864.58	86.95	782.40	1,729.39	223.95	3,929.83	1,993.55	6,138.77
1999	881.61	85.44	780.86	1,742.44	249.84	4,412.25	1,879.44	6,538.26
2000	929.39	79.60	831.54	1,835.37	256.23	4,417.03	2,024.61	6,699.35
2001	901.40	77.31	781.66	1,754.75	249.37	4,502.31	2,005.23	6,756.89
2002	916.57	83.65	899.28	1,899.50	252.11	4,587.59	2,083.23	6,922.93
2003	997.61	87.06	750.47	1,835.14	221.09	4,332.66	2,058.21	6,611.96
2004	971.24	83.58	1,007.18	2,060.04	142.41	4,333.79	2,039.51	6,522.74
2005	990.64	91.52	860.19	1,943.35	111.43	4,322.64	1,882.41	6,328.90
2006	1,107.94	87.87	1,005.95	2,201.55	89.35	4,068.23	2,228.93	6,411.51
2007	1,114.67	98.39	1,001.67	2,215.84	55.54	3,758.28	3,763.18	7,619.40
2008	1,246.05	116.42	944.97	2,316.59	48.31	3,569.30	3,448.15	7,106.10
2009	1,108.71	104.05	908.46	2,129.60	48.78	2,951.43	3,061.06	6,092.11
2010	1,302.90	100.29	1,000.06	2,414.64	43.81	3,767.26	3,307.53	7,146.76
201	1,322.80	98.19	1,010.	2,442.	33.63	3,004.5	3,177.	6,237.

1			63	73		8	69	26
2012	1,278.23	116.41	952.97	2,363.89	31.51	3,472.50	3,514.77	7,047.49
2013	1,133.59	110.94	957.67	2,214.69	28.95	2,926.64	3,480.93	6,452.42
2014	1,118.55	109.82	1,005.10	2,246.41	26.39	2,900.51	3,328.44	6,274.51
2015	1,020.56	110.71	1,033.54	2,179.99	22.41	2,780.31	3,474.66	6,284.64
2016	821.45	117.35	1,047.96	2,007.79	26.53	2,620.34	3,537.38	6,178.96
2017	1,002.68	149.41	1,126.12	2,310.85	36.12	2,437.43	3,780.83	6,233.28
2018	850.48	151.33	1,089.51	2,114.07	34.49	2,703.60	3,870.02	6,601.59

Annex 2.12 Cont.

Year	**Chonburi**				**Chachoengsao**			
	Agriculture	**Industrial**	**Services**	**GPP**	**Agriculture**	**Industrial**	**Services**	**GPP**
1995	165.93	3,434.73	2,147.15	5,724.37	276.24	2,100.95	935.78	3,300.10
1996	185.52	3,799.57	2,265.51	6,228.48	293.98	2,201.53	1,030.90	3,512.98
1997	192.59	3,676.32	2,248.92	6,099.06	328.94	2,304.00	1,063.53	3,686.49
1998	195.46	2,992.98	2,095.14	5,275.42	354.33	1,906.40	944.05	3,210.92
1999	200.62	3,116.60	2,082.35	5,396.81	326.65	1,935.73	886.78	3,149.77
2000	211.44	3,263.02	2,108.42	5,580.46	343.14	1,937.61	866.25	3,149.45
2001	218.22	3,108.97	2,133.18	5,459.04	361.61	1,870.82	883.44	3,117.61
2002	226.71	3,332.21	2,136.81	5,695.72	342.73	2,228.66	931.83	3,503.22
2003	242.46	3,528.23	2,174.17	5,944.86	399.68	3,031.63	1,028.12	4,459.42
2004	180.70	3,850.44	2,348.00	6,385.54	342.99	3,521.70	1,131.04	5,004.66
2005	180.35	4,319.31	2,429.46	6,926.25	332.38	3,417.47	1,164.77	4,925.12
2006	187.45	4,725.47	2,553.62	7,462.37	363.31	3,820.57	1,234.04	5,423.33
2007	191.28	5,075.01	2,632.95	7,900.60	377.70	4,376.17	1,310.44	6,059.72
2008	189.97	5,116.18	2,595.59	7,906.80	376.69	4,600.06	1,351.53	6,319.59

2009	180.60	4,566.40	2,360.85	7,111.45	368.25	3,847.45	1,286.41	5,522.48
2010	174.91	4,478.28	2,544.45	7,199.53	337.18	4,821.69	1,419.37	6,557.52
2011	182.92	4,380.73	2,589.41	7,154.27	375.02	4,800.28	1,413.20	6,579.25
2012	173.32	3,840.86	2,762.83	6,771.30	354.11	6,498.85	1,652.88	8,404.85
2013	175.66	3,946.12	2,880.29	6,995.42	352.04	5,859.12	1,576.08	7,721.19
2014	147.30	4,000.99	2,940.00	7,078.52	344.60	5,710.14	1,519.53	7,508.56
2015	139.12	4,097.18	3,039.41	7,263.52	325.15	5,366.81	1,534.03	7,179.97
2016	148.47	4,176.69	3,278.13	7,580.03	313.95	5,714.92	1,528.21	7,482.07
2017	163.65	4,065.96	3,353.10	7,545.61	333.22	5,441.91	1,530.83	7,258.65
2018	167.99	3,938.12	3,501.62	7,547.45	329.43	6,091.84	1,627.28	7,969.54

Annex 2.12 Cont.

Year	Samut Sakhon				Samut Songkhram			
	Agriculture	Industrial	Services	GPP	Agriculture	Industrial	Services	GPP
1995	324.59	6,028.00	2,080.25	8,422.48	183.77	443.62	595.78	1,216.81
1996	278.28	5,965.51	2,085.93	8,323.43	174.99	462.83	653.33	1,287.42
1997	313.64	5,742.30	2,190.87	8,236.75	164.84	461.67	623.45	1,246.33
1998	331.31	4,485.98	1,823.76	6,628.97	136.14	397.78	584.89	1,117.34
1999	326.71	4,567.38	1,657.51	6,547.47	106.30	374.40	570.82	1,050.55
2000	290.91	4,927.22	1,708.41	6,923.91	150.44	395.29	611.79	1,155.49
2001	299.27	4,959.26	1,720.10	6,976.11	163.19	372.78	783.40	1,318.12
2002	275.35	5,188.08	1,612.42	7,075.85	113.55	378.27	595.08	1,086.90
2003	620.89	5,483.47	1,627.10	7,731.46	111.35	426.64	649.63	1,187.62
2004	550.44	5,571.73	1,632.89	7,759.42	124.94	456.56	698.09	1,280.45
2005	421.68	5,324.81	1,539.12	7,305.19	162.30	477.15	788.67	1,433.38
200	538.76	5,264.5	1,463.	7,257.	183.48	507.50	855.78	1,553.

6		0	19	02				71
2007	553.30	5,181.76	1,450.87	7,171.05	174.72	534.06	788.97	1,503.20
2008	605.97	5,023.91	1,373.36	6,964.29	165.34	554.59	823.37	1,545.45
2009	512.39	4,853.60	1,252.45	6,602.07	167.23	505.34	867.31	1,541.38
2010	556.26	5,084.20	1,304.65	6,920.27	138.87	502.82	866.52	1,500.96
2011	534.29	4,796.43	1,307.72	6,619.62	154.92	523.42	871.80	1,546.72
2012	522.79	4,708.73	1,325.55	6,542.64	144.83	397.66	959.19	1,487.33
2013	538.68	4,481.20	1,307.47	6,305.12	136.97	401.09	964.41	1,486.35
2014	483.71	4,502.44	1,370.22	6,359.87	150.78	401.36	1,009.27	1,546.99
2015	394.84	4,370.83	1,393.35	6,186.86	136.60	403.88	1,058.66	1,576.74
2016	295.94	4,436.99	1,439.48	6,226.35	130.17	416.60	1,074.69	1,595.91
2017	149.03	4,583.97	1,441.49	6,250.55	253.56	420.59	1,188.29	1,882.71
2018	133.41	4,657.86	1,528.15	6,407.14	289.53	436.63	1,218.19	1,978.43

Annex 2.12 Cont.

Year	Phetchaburi				Prachuap Khiri khan			
	Agriculture	Industrial	Services	GPP	Agriculture	Industrial	Services	GPP
1995	125.34	152.59	888.81	1,155.53	422.42	608.59	786.66	1,771.26
1996	124.80	156.59	967.06	1,235.43	393.69	587.95	878.15	1,818.38
1997	133.90	165.08	978.72	1,265.61	377.64	544.51	804.96	1,688.26
1998	141.43	279.82	868.35	1,278.85	328.97	392.80	767.84	1,456.08
1999	141.63	496.83	922.07	1,563.98	366.44	702.59	773.28	1,827.54
2000	155.47	555.17	924.28	1,639.82	391.34	793.34	788.58	1,958.00
2001	168.50	427.23	946.14	1,539.23	349.84	762.93	811.63	1,917.66
2002	159.95	488.46	939.89	1,588.31	340.89	737.51	917.03	1,995.43
2003	173.64	508.30	938.17	1,620.11	334.66	827.76	944.37	2,106.79

2004	198.46	535.76	1,024.90	1,759.15	368.72	816.27	1,043.74	2,229.26
2005	192.24	553.69	1,033.09	1,778.34	391.97	816.54	1,126.13	2,333.61
2006	211.66	588.32	1,008.16	1,809.20	534.49	866.29	1,122.28	2,516.55
2007	218.28	595.53	1,041.56	1,856.52	570.48	770.80	1,157.26	2,488.97
2008	213.98	557.36	1,022.71	1,796.37	586.93	832.35	1,170.43	2,578.90
2009	209.47	522.79	1,045.19	1,777.91	542.69	798.88	1,117.58	2,450.77
2010	200.19	558.73	1,118.03	1,871.23	539.27	854.79	1,182.56	2,570.70
2011	193.83	567.16	1,048.86	1,807.04	598.87	938.47	1,175.65	2,705.35
2012	219.87	544.89	1,233.70	1,985.00	564.20	891.65	1,255.44	2,702.09
2013	214.08	525.96	1,183.20	1,911.58	537.82	946.02	1,262.75	2,739.91
2014	206.00	511.19	1,121.97	1,829.45	542.70	872.03	1,309.19	2,719.37
2015	173.52	518.38	1,150.36	1,822.34	531.20	843.99	1,372.94	2,745.41
2016	172.69	533.36	1,151.03	1,836.99	518.04	901.26	1,413.99	2,831.49
2017	178.55	622.23	1,208.66	1,987.29	629.92	985.49	1,500.62	3,117.08
2018	204.97	560.22	1,274.93	2,020.30	731.97	971.31	1,575.23	3,283.51

Annex 2.12 Cont.

Year	**Nakhon Si Thammarat**				**Sarat Thani**			
	Agriculture	**Industrial**	**Services**	**GPP**	**Agriculture**	**Industrial**	**Services**	**GPP**
1995	249.98	225.82	508.21	1,005.88	361.60	327.59	861.75	1,544.32
1996	258.84	289.61	545.59	1,107.86	396.86	322.40	924.24	1,641.18
1997	251.57	364.71	550.33	1,168.41	361.27	343.97	830.48	1,531.10
1998	264.47	320.07	550.72	1,142.19	357.91	300.73	852.01	1,509.15
1999	295.19	332.16	601.49	1,236.81	386.99	368.07	862.60	1,617.03
2000	312.26	368.01	505.00	1,184.11	406.14	296.87	830.14	1,530.53
200	308.90	376.46	489.89	1,173.	435.43	293.36	831.65	1,553.

1				56				80
2002	310.48	402.12	530.50	1,243.10	420.06	334.37	871.24	1,625.66
2003	338.31	414.93	565.50	1,318.74	463.76	355.95	911.26	1,730.97
2004	362.22	446.46	588.06	1,397.67	470.67	396.97	1,064.19	1,919.95
2005	337.90	450.32	609.36	1,394.27	465.78	401.86	1,119.67	1,966.93
2006	330.90	387.64	607.93	1,325.86	478.51	403.05	1,266.94	2,111.32
2007	330.49	411.96	619.34	1,358.34	430.93	421.35	1,166.89	1,979.64
2008	314.31	340.99	582.45	1,238.48	474.49	393.24	1,215.59	2,057.33
2009	335.48	419.33	616.92	1,371.22	464.04	403.57	1,175.65	2,019.21
2010	328.36	512.11	687.91	1,521.96	449.05	451.29	1,256.67	2,115.13
2011	268.86	441.73	700.26	1,383.92	432.07	456.24	1,328.08	2,144.25
2012	284.97	441.99	737.50	1,439.51	490.29	464.84	1,410.19	2,319.60
2013	346.95	408.96	714.86	1,474.18	555.14	479.62	1,436.51	2,460.38
2014	356.56	395.92	663.86	1,427.46	504.40	495.73	1,387.64	2,359.72
2015	322.16	392.38	685.53	1,406.91	478.49	502.06	1,475.67	2,411.90
2016	324.40	363.83	732.02	1,427.23	444.44	499.39	1,536.20	2,425.67
2017	342.82	366.84	744.42	1,462.63	445.60	534.53	1,631.70	2,546.58
2018	374.43	349.19	753.81	1,491.17	457.57	467.74	1,677.54	2,541.20

Annex 2.12 Cont.

Year	Chumphon				Songkhla			
	Agriculture	**Industrial**	**Services**	**GPP**	**Agriculture**	**Industrial**	**Services**	**GPP**
1995	430.72	260.15	663.85	1,330.81	406.90	417.95	1,136.18	1,967.83
1996	525.26	254.81	768.61	1,532.17	397.48	389.00	1,114.39	1,908.49
1997	532.44	244.66	692.25	1,457.31	374.88	395.26	1,081.48	1,857.70
1998	559.41	232.50	739.75	1,521.37	422.76	384.93	1,038.60	1,851.57

1999	664.95	275.76	778.89	1,718.14	403.10	416.23	1,034.80	1,860.24
2000	567.71	219.98	646.22	1,434.98	432.86	501.53	952.57	1,885.86
2001	570.58	166.96	635.55	1,376.10	442.97	496.18	953.57	1,891.42
2002	644.59	172.92	677.74	1,495.25	426.09	498.73	984.63	1,909.45
2003	635.80	186.26	695.44	1,517.50	436.88	538.52	1,026.02	2,001.42
2004	698.72	187.72	753.83	1,640.73	458.05	525.67	1,050.42	2,034.64
2005	689.05	204.98	783.60	1,674.09	474.85	610.02	1,074.78	2,163.68
2006	707.07	224.07	810.22	1,736.68	478.28	619.86	1,060.87	2,164.50
2007	748.65	239.98	846.15	1,830.85	449.53	619.32	1,061.52	2,131.87
2008	771.76	271.40	861.71	1,899.57	413.59	642.39	1,024.56	2,082.38
2009	806.83	251.75	898.16	1,954.39	385.76	692.76	1,010.45	2,093.23
2010	697.29	261.56	922.65	1,865.24	352.84	753.65	1,126.31	2,238.18
2011	628.99	264.61	905.32	1,766.74	347.15	730.16	1,144.22	2,222.54
2012	640.30	276.95	924.51	1,807.16	404.66	723.69	1,157.02	2,306.70
2013	751.42	294.11	922.31	1,964.93	404.37	817.88	1,155.05	2,406.19
2014	738.25	297.21	894.73	1,928.18	385.80	815.53	1,069.55	2,303.43
2015	638.69	291.24	925.51	1,831.99	368.19	841.71	1,143.23	2,388.12
2016	742.13	262.30	1,045.48	2,030.44	365.57	825.67	1,163.24	2,388.67
2017	718.88	244.92	1,056.20	1,994.35	322.53	777.22	1,158.52	2,293.91
2018	817.25	250.64	1,096.81	2,158.90	357.84	746.70	1,228.82	2,367.37

Annex 2.12 Cont.

Year	**Pattani**				**Narathiwat**			
	Agriculture	**Industrial**	**Services**	**GPP**	**Agriculture**	**Industrial**	**Services**	**GPP**
1995	674.27	76.87	511.08	1,260.84	179.75	59.83	416.59	659.34
199	642.67	78.74	531.12	1,253.	199.11	62.99	442.05	708.

6				56				99
1997	622.93	78.81	524.04	1,227.27	209.88	62.56	405.52	684.74
1998	585.56	74.79	510.41	1,172.66	235.30	62.44	400.77	703.19
1999	583.87	79.15	547.28	1,212.00	225.76	59.24	409.05	699.32
2000	600.74	44.00	487.59	1,133.29	202.00	63.22	348.84	616.88
2001	556.37	78.14	464.58	1,099.64	200.73	59.54	353.51	617.11
2002	577.45	74.31	502.20	1,153.95	230.25	60.15	368.85	659.25
2003	550.10	72.62	493.82	1,116.54	321.49	57.94	402.27	781.70
2004	526.72	106.73	525.22	1,160.70	311.13	54.54	431.33	793.71
2005	554.32	116.62	515.20	1,185.78	312.15	54.36	448.74	810.06
2006	576.98	121.83	506.19	1,201.78	320.29	55.52	482.37	849.42
2007	534.34	122.15	485.18	1,139.98	343.02	56.90	470.38	871.78
2008	586.42	127.75	472.61	1,176.36	317.63	56.68	461.08	831.14
2009	639.63	127.68	507.37	1,260.40	345.39	54.72	479.75	879.81
2010	616.48	146.81	550.53	1,318.19	332.16	54.17	548.15	922.80
2011	575.84	155.87	588.87	1,338.29	314.82	55.91	581.01	921.89
2012	563.45	185.53	621.58	1,398.36	222.80	47.56	516.04	727.97
2013	586.44	159.11	622.79	1,389.59	216.58	45.74	482.12	692.90
2014	568.22	158.35	592.90	1,339.51	242.64	47.47	456.07	707.35
2015	490.47	154.35	630.06	1,311.13	207.02	47.54	483.80	691.22
2016	480.24	181.78	661.69	1,371.03	205.37	49.43	501.32	707.11
2017	308.86	117.71	629.19	1,111.58	159.27	48.85	505.01	659.91
2018	356.77	108.73	657.00	1,175.02	220.61	50.05	518.37	742.49

Annex 2.12 Cont.

Year	Bangkok				Thailand			
	Agriculture	**Industrial**	**Services**	**GPP**	**Agriculture**	**Industrial**	**Services**	**Total**
1995	5.78	1,070.88	6,108.88	7,192.76	162.29	612.65	1,225.84	1,999.42
1996	4.60	1,103.92	6,244.88	7,360.75	169.04	645.10	1,277.05	2,089.63
1997	4.69	1,025.17	5,645.91	6,681.42	166.41	649.07	1,197.08	2,010.16
1998	4.49	1,096.20	4,919.69	6,020.64	165.74	594.82	1,077.21	1,836.67
1999	4.28	1,130.95	5,019.40	6,154.74	171.86	639.81	1,089.05	1,899.92
2000	4.81	1,193.65	5,365.61	6,564.38	181.57	658.26	1,124.17	1,963.15
2001	5.53	1,184.52	5,545.05	6,735.16	186.09	671.09	1,162.72	2,019.12
2002	6.39	1,118.07	5,690.76	6,815.22	185.23	724.64	1,221.12	2,130.99
2003	5.49	1,139.75	5,840.90	6,986.14	206.19	789.66	1,275.26	2,271.10
2004	5.00	1,163.22	6,122.56	7,290.11	202.72	841.33	1,356.70	2,400.10
2005	4.84	1,154.96	6,318.27	7,476.01	201.44	877.40	1,409.03	2,486.28
2006	4.74	1,135.59	6,373.11	7,510.44	208.15	921.56	1,466.94	2,594.83
2007	4.91	1,209.67	6,295.02	7,511.48	210.90	978.70	1,533.31	2,720.18
2008	4.92	1,101.25	6,247.98	7,351.78	215.84	1,001.77	1,535.08	2,751.26
2009	4.73	1,039.43	6,042.01	7,082.81	214.08	972.76	1,531.79	2,716.60
2010	4.65	1,009.69	6,272.64	7,279.66	211.88	1,069.81	1,628.24	2,903.97
2011	4.38	1,056.51	6,512.86	7,566.88	223.84	1,019.38	1,671.03	2,910.36
2012	4.26	1,113.30	6,911.79	8,021.19	228.48	1,086.50	1,797.48	3,101.97
2013	4.45	1,201.28	7,255.27	8,455.58	228.67	1,098.23	1,853.25	3,165.75
2014	4.06	1,207.82	7,484.02	8,687.44	226.61	1,092.46	1,875.20	3,177.23
2015	3.96	1,190.78	7,815.89	8,996.63	210.65	1,106.77	1,968.20	3,256.66
2016	3.72	1,204.48	8,116.23	9,307.58	207.19	1,125.98	2,053.20	3,351.97

2017	3.72	1,140.44	8,496.11	9,614.34	215.67	1,141.90	2,145.66	3,467.74
2018	3.49	1,177.27	8,861.98	10,014.50	227.80	1,169.85	2,236.10	3,598.12

Annex 2.13 Sustainable fisheries as a percentage of GDP in Thailand (2011-2021)

Year	%
2011	0.45
2013	0.36
2015	0.33
2017	0.3
2019	0.31
2021	0.28

Source: FAO. 2025. Sustainable fisheries as a proportion of GDP. https://de-public-statsuite.fao.org/ (Accessed 25 June 2025)

Annex 2.14 Tourism as a percentage of GDP in Thailand (2011-2021)

Year	%
2010	3.6
2011	4.2
2012	4.7
2013	5.3
2014	5.2
2015	6.2
2016	5.9
2017	7.4
2018	7.4
2019	7.4
2020	2.3
2021	0.8

Source: Our World in Data. 2024. Tourism's contribution to GDP. https://www.unwto.org/tourism-statistics/economic-contribution-SDG (Accessed 25 June 2025)

Annex 2.15 Number of tropical cyclones per year of Thailand (2000-2024) from Thai Meteorological Department (TMD) and EM-DAT

Year	TMD	EM-DAT
2000	3	1
2001	1	0
2002	0	0
2003	2	0
2004	2	1
2005	3	1
2006	2	0
2007	3	0
2008	1	2
2009	1	0
2010	1	0
2011	1	1
2012	1	0
2013	2	0
2014	0	0
2015	1	1
2016	2	0
2017	3	2
2018	2	0
2019	3	1
2020	3	3
2021	1	0
2022	1	0
2023	0	0
2024	1	1

Source: EM-DAT, CRED / UCLouvain. 2025. www.emdat.be (Accessed 25 Jun 2025); TMD. 2025. Tropical Cyclones in Thailand (1951-2024).

Annex 2.16 Number of deaths from tropical cyclones per year of Thailand (2000-2024)

Year	Total Deaths
2000	2
2004	1
2005	10
2008	0
2011	18
2015	3
2017	0
2019	7
2020	11
2024	45

Source: EM-DAT, CRED / UCLouvain. 2025. www.emdat.be (Accessed 25 Jun 2025)

Annex 2.17 Total damage and total damage (adjusted) due to tropical cyclones of Thailand (2000-2024)

End Year	Total Damage ('000 US$)	Total Damage, Adjusted ('000 US$)
2000	-	-
2004	-	-
2005	20,000.00	32,125.00
2008	-	-
2011	-	-
2015	561.00	742.00
2017	-	-
2019	-	-
2020	-	-
2024	904,000.00	904,000.00

Source: EM-DAT, CRED / UCLouvain. 2025. www.emdat.be (Accessed 25 Jun 2025)

Annex 2.18 Key demographic trends and normalized indices by province (2000–2020)

Province	Pop 2000	Pop 2020	CAGR_Pop	I_{Pop}	HH 2000	HH 2020	CAGR_HH	I_{HH}	PopDens2020	$I_{PopDense2020}$
	Persons	Persons	%		Unit	Unit	%		persons/km2	
Rayong	523,518	741,524	1.76	0.94	190,527	506,761	5.01	1.00	209	0.04
Chanthaburi	493,434	535,559	0.41	0.33	149,732	243,727	2.47	0.10	84	0.00
Trat	223,924	228,536	0.10	0.19	70,386	108,270	2.18	0.00	81	0.00
Samut Prakan	995,838	1,351,479	1.54	0.84	363,684	711,804	3.41	0.44	1346	0.36
Chon Buri	1,078,518	1,566,885	1.89	1.00	426,953	1,070,209	4.70	0.89	359	0.08
Chachoengsao	639,751	720,718	0.60	0.42	175,139	313,586	2.96	0.27	135	0.02
Samut Sakhon	428,814	586,199	1.58	0.86	161,658	296,825	3.08	0.32	672	0.17
Samut Songkhram	204,995	192,052	-0.33	0.00	45,642	72,732	2.36	0.06	461	0.11
Phetchaburi	456,893	482,193	0.27	0.27	130,928	220,362	2.64	0.16	77	0.00
Prachuap Khiri Khan	478,944	550,678	0.70	0.46	138,021	271,890	3.45	0.45	86	0.00
Nakhon Si Thammarat	1,524,558	1,550,721	0.09	0.19	368,401	581,948	2.31	0.05	156	0.02
Surat-Thani	893,534	1,067,726	0.89	0.55	255,988	512,366	3.53	0.48	83	0.00
Chumphon	463,394	509,208	0.47	0.36	139,964	240,248	2.74	0.20	85	0.00
Songkhl	1,23	1,42	0.74	0.	311,	553,	2.92	0.	193	0.03

a	2,600	8,609		48	407	597		26		
Pattani	612,127	726,015	0.86	0.53	123,863	195,224	2.30	0.04	374	0.09
Narathiwat	679,135	804,429	0.85	0.53	139,040	219,403	2.31	0.05	180	0.03
Bangkok	5,680,380	5,588,222	-0.08	0.11	1,900,235	3,103,483	2.48	0.11	3562	1.00

Annex 2.18 Cont.

Prov	**Poor2000**	**Poor2020**	**CAGR_Poor**	**I_{Poor}**	**GPP2000**	**GPP2020**	**CAGRGPP**	**I_{GPP}**	**SexRatio2020**	**Imbalance**	**$I_{imbalance}$**
	Persons	**Persons**	**%**		**USDpercapita**	**USDpercapita**	**%**		**%**		
Rayong	127,874	4,885	-15.06	0.40	10,815.23	11,050.56	0.11	0.27	96.52	3.48	0.18
Chanthaburi	213,073	36,687	-8.42	0.69	1,895.08	2,465.76	1.32	0.51	95.79	4.21	0.25
Trat	106,881	30,551	-6.07	0.79	1,835.37	2,247.54	1.02	0.45	98.03	1.97	0.02
Samut Prakan	58,988	4,363	-12.21	0.52	6,699.35	5,199.45	-1.26	0.00	91.17	8.83	0.74
Chon Buri	174,150	664	-24.31	0.00	5,580.46	6,924.99	1.09	0.46	95.15	4.85	0.32
Chachoengsao	144,030	12,007	-11.68	0.55	3,149.45	6,633.61	3.79	1.00	96.23	3.77	0.21
Samut Sakhon	129,917	13,126	-10.83	0.58	6,923.91	6,460.07	-0.35	0.18	93.16	6.84	0.53
Samut Songkhram	28,122	11,570	-4.34	0.87	1,155.49	2,100.15	3.03	0.85	91.62	8.38	0.69
Phetchaburi	182,488	17,182	-11.14	0.57	1,639.82	1,987.10	0.97	0.44	93.44	6.56	0.50
Prachuap	212,532	18,214	-11.56	0.5	1,958.00	3,048.16	2.24	0.6	98.21	1.79	0.00

Khiri Khan				5				9			
Nakhon Si Thammarat	817,455	146,929	-8.22	0.70	1,184.11	1,603.30	1.53	0.55	97.46	2.54	0.08
Surat-Thani	188,191	34,485	-8.13	0.70	1,530.53	2,154.75	1.73	0.59	96.99	3.01	0.13
Chumphon	119,834	31,896	-6.40	0.78	1,434.98	2,637.19	3.09	0.86	97.49	2.51	0.08
Songkhla	416,353	100,439	-6.86	0.76	1,885.86	2,166.57	0.70	0.39	95.10	4.9	0.33
Pattani	367,810	285,400	-1.26	1.00	1,133.29	1,132.12	-0.01	0.25	97.61	2.39	0.06
Narathiwat	485,521	182,235	-4.78	0.85	616.88	687.28	0.54	0.36	97.78	2.22	0.04
Bangkok	372,589	44,112	-10.12	0.62	6,564.38	9,670.83	1.96	0.64	88.65	11.35	1.00

Annex 2.19 Summary of Calculated Risk Indices and Provincial Rankings

Provinces	**Score$_{P1}$**	**PI**	**VI**	**CRI$_{UnWeighted}$**	**CRI$_{Final}$**	**Area Weight**	**Rank$_{CRI Final}$**	**Rank$_{CRIUnweighted}$**
Rayong	0.968	0.425	0.098	0.261	0.011	0.044	12	17
Chanthaburi	0.236	0.249	0.378	0.314	0.024	0.078	6	12
Trat	0.097	0.183	0.346	0.265	0.009	0.035	13	15
Samut Prakan	0.634	0.332	0.506	0.419	0.005	0.012	15	3
Chon Buri	0.948	0.497	0.160	0.329	0.018	0.054	9	11
Chachoengsao	0.358	0.458	0.253	0.355	0.023	0.066	7	8
Samut Sakhon	0.597	0.316	0.438	0.377	0.004	0.011	16	4
Samut Songkhram	0.052	0.337	0.740	0.538	0.003	0.005	17	2
Phetchaburi	0.218	0.219	0.452	0.336	0.026	0.076	5	10
Prachuap Khiri Khan	0.469	0.387	0.148	0.268	0.021	0.078	8	14
Nakhon Si Thammarat	0.118	0.231	0.293	0.262	0.032	0.122	3	16
Surat-Thani	0.517	0.369	0.326	0.348	0.055	0.158	1	9

Chumphon	0.286	0.382	0.362	0.372	0.027	0.074	4	5
Songkhla	0.372	0.264	0.470	0.367	0.033	0.091	2	7
Pattani	0.295	0.209	0.531	0.370	0.009	0.024	14	6
Narathiwat	0.293	0.226	0.401	0.314	0.017	0.055	10	13
Bangkok	0.125	0.586	0.706	0.646	0.012	0.019	11	1

Annex II: Ecosystems

Indicator Assessment

- **Geographic information**

Total area, areas of mangrove, forest, area of tidal flats (beach forest, peat swamp forest), and area of seagrass beds

Across the five focal sites, the combined wetland extent is 2,613.68 km². Mangrove forests account for 480.69 km² (≈18.4%), with the largest tracts in Bandon Bay (255.70 km²; ≈51.7% of the site), followed by Pak Phanang Bay (90.00 km²; ≈66.2%) and the Welu River Estuary (72.06 km²; ≈69.3%). Samut Prakan Province has the greatest total area (1,004.12 km²) but retains a relatively small mangrove remnant (33.74 km²; ≈3.36%), while Don Hoi Lot spans 875.00 km² with 29.19 km² of mangroves (≈3.34%). The reported tidal-flat area totals 25.20 km², concentrated in Don Hoi Lot (24.09 km²) and Pak Phanang Bay (1.11 km²). No peat-swamp or seagrass-bed extents were reported in this compilation for the five sites. Collectively, these figures reveal a heterogeneous coastal mosaic in which extensive mangrove belts remain at Welu and Pak Phanang,a mixed natural–mariculture seascape defines Bandon Bay, and large but highly managed coastal plains characterize Samut Prakan and Don Hoi Lot (Table 1).

Table 1. Mangroves and wetland areas in Thailand (Gulf of Thailand): Geographic information showing total area, areas of mangrove, forest, area of tidal flats (beach forest, peat swamp forest), and area of seagrass beds

Name of area	Total area (km^2)	Areas of mangrove forest (km^2)	Area of tidal flats (km^2)		Area of seagrass beds (km^2)
			Beach Forest	Peat swamp forest	
MG1: Welu River Estuary	104.00	72.06	**-**	**-**	**-**
MG2: Bandon Bay	494.59	255.70	**-**	**-**	**-**
MG3: Pak Panang Bay	135.97	90.00	1.11	**-**	**-**
MG: Samut Prakan Province	1,004.12	33.74	**-**	**-**	**-**
WL1: Don Hoi Lot	875.00	29.19	24.09	**-**	**-**
Total	**2,613.68**	**480.69**	**25.20**	**-**	**-**

- **Social and use information**

Ownership, management regime, current use and potential use

The five coastal and estuarine study sites—Welu River Estuary, Bandon Bay, Pak Panang Bay, Samut Prakan Province, and Don Hoi Lot—are all under state ownership and managed through various multi-agency and community partnerships, emphasizing ecosystem restoration, sustainable resource use, and participatory coastal management.

Under management regimes, these areas are overseen primarily by the Department of Marine and Coastal Resources (DMCR), in collaboration with local authorities, the Department of Fisheries, and community organizations. Co-management frameworks, research partnerships, and integrated coastal management (ICM) initiatives play a key role in maintaining ecosystem services and supporting community livelihoods.

In terms of current use, all sites support both commercial and subsistence activities, including fisheries, aquaculture, small-scale harvesting, and ecotourism. Welu River Estuary and Bandon Bay serve as hubs for aquaculture and local transport, while Pak Panang Bay functions as a major seafood production area. Samut Prakan's coastal zone supports industrial, fishing, and educational uses, whereas Don Hoi Lot is renowned for its shellfish harvesting and coastal ecotourism.

Regarding potential use, opportunities exist for enhancing ecotourism, blue carbon initiatives, mangrove restoration, and community-based resource co-management. Additional strategies include marine-use zoning, pollution control, and sustainable aquaculture certification, aimed at aligning local livelihoods with conservation goals. Collectively, these initiatives demonstrate the balance between economic utilization and ecological protection in Thailand's coastal management framework. (Table 2).

Table 2. Mangroves and wetland areas in Thailand (Gulf of Thailand): Social and use information showing ownership, management regime, current use and potential use

Name of area	Ownership	Management regime	Current use	Potential use
MG1: Welu River Estuary	State	Managed by the Mangrove Resource Development Station 2 (DMCR); research and	Commercial Use: The estuary supports small-scale and commercial fisheries, aquaculture	Formal co-management with communities; interpretive trails & eco-tourism upgrades; blue-carbon

Name of area	Ownership	Management regime	Current use	Potential use
		restoration in partnership with local communities and universities.	(mainly shrimp and shellfish farms), and small-boat transport connecting local communities to the Gulf of Thailand. Ecotourism and community-based tourism activities—such as mangrove trails, birdwatching, and educational tours—are also growing. Subsistence Use: Local villagers depend on the estuary for daily livelihoods through harvesting shellfish, crabs, and small fish from mudflats and mangrove creeks. They also use mangrove resources for fuelwood, honey, and traditional medicine. Many households combine small-scale aquaculture with seasonal fishing to maintain food security and supplement income year-round.	projects and rehabilitation of degraded patches.
MG2: Bandon Bay	State	Multi-agency: Department of Fisheries	Commercial Use: Bandon Bay is a major	Formal marine-use zoning; wastewater/pollution

Name of area	Ownership	Management regime	Current use	Potential use
		(mariculture, water quality) and DMCR for mangroves; provincial integrated coastal management and mariculture-zoning initiatives.	fishing and aquaculture zone in southern Thailand, supporting large-scale shrimp, crab, and oyster farming that supplies both local and export markets. The bay also serves as a key waterway for fishing and transport activities, while community-based ecotourism and seafood-related tourism are expanding along the coast. Subsistence Use: Local communities rely on traditional fishing and shellfish collection from mangrove creeks and tidal flats for food and income. Mangrove forests provide essential household resources such as fuelwood and honey. Many families integrate small-scale aquaculture, seasonal fishing, and ecotourism activities to sustain year-round livelihoods and maintain food security.	reduction; mangrove & tidal-flat restoration; sustainable shellfish eco-label/traceability.
MG3: Pak Panang Bay	State	Part of the Pak Phanang	Commercial Use:	Integrated Coastal

Name of area	Ownership	Management regime	Current use	Potential use
		River Basin development/sluice scheme (RID); state mangroves under protection and replanting (DMCR); requires cross-agency ICM.	Pak Panang Bay supports major fisheries and aquaculture activities, particularly shrimp, crab, and shellfish farming, which drive the local economy. The bay also functions as a vital fishing and transport route, facilitating seafood trade and coastal commerce. Ecotourism and wetland-based tourism, focusing on mangroves, birds, and coastal culture, are emerging economic opportunities. Subsistence Use: Local communities depend on traditional fishing, shellfish gathering, and small-scale aquaculture for household food and income. Mangrove forests provide essential resources such as fuelwood, honey, and medicinal plants. Many families practice mixed livelihoods, combining natural resource use, farming, and community	Management with clear activity zones; expand mangrove rehabilitation; continuous water-quality & sediment monitoring.

Name of area	Ownership	Management regime	Current use	Potential use
			tourism to sustain food security and adapt to changing environmental and economic conditions.	
MG: Samut Prakan Province	State	Key sites include Bang Pu Nature Education/Recreation Area (operated with the Royal Thai Army's Quartermaster Dept. and partners); Bang Kachao / Sri Nakhon Khuean Khan Park under local/state arrangements; public-private mangrove restoration.	Commercial Use: Samut Prakan serves as a major industrial and coastal economic hub, with activities including marine and estuarine fisheries, aquaculture, seafood processing, and port operations. The lower Chao Phraya River estuary supports shrimp and fish farms, while offshore fishing in the upper Gulf of Thailand remains active. Rapid urbanization and industrial expansion have transformed coastal landscapes, increasing demand for land reclamation, logistics, and coastal infrastructure. Subsistence Use: Traditional fishing and small-scale aquaculture still persist in some riverside and coastal communities,	Listing/strengthening as a flyway network site for migratory waterbirds; ongoing CSR-led mangrove/blue-carbon projects; urban/industrial pollution control to coastal waters.

Name of area	Ownership	Management regime	Current use	Potential use
			providing food and supplementary income. Local residents also utilize remaining mangrove areas for small-scale resource gathering such as fuelwood and honey. Additionally, community-based mangrove restoration and eco-learning tourism projects have emerged, promoting environmental awareness and sustaining local livelihoods amid urban and industrial growth.	
WL1: Don Hoi Lot	State	Ramsar-listed wetland (Don Hoi Lot); nationally designated Restricted Preservation Area with an approved site management plan.	Commercial Use: Don Hoi Lot is a key site for shellfish harvesting and coastal tourism in Samut Songkhram Province. It supports commercial fisheries and aquaculture, particularly for blood cockles and other bivalves that are important for local trade and seafood markets. The area also attracts significant ecotourism, including mudflat excursions, seafood tasting,	Co-managed shellfish fishery with closed seasons/reserves; visitor-use management and water-quality safeguards; mangrove restoration and waterbird monitoring.

Name of area	Ownership	Management regime	Current use	Potential use
			and mangrove learning tours, which generate income for local communities. Subsistence Use: Local residents rely on traditional shellfish gathering, crab trapping, and small-scale fishing for food and supplemental income. Mangrove forests surrounding the area provide resources such as fuelwood, honey, and medicinal plants. Many households integrate resource use with community-based tourism and conservation, participating in mangrove restoration and co-management activities to sustain local livelihoods and protect coastal ecosystems.	

Significance/national importance and protection status

The five study sites—Welu River Estuary, Bandon Bay, Pak Panang Bay, Samut Prakan Province, and Don Hoi Lot—represent nationally important coastal and wetland ecosystems that contribute significantly to Thailand's blue economy, biodiversity conservation, and climate resilience. Each area plays a distinct ecological and socio-economic role.

The Welu River Estuary supports national strategies for sustainable coastal management and blue carbon initiatives, while Bandon Bay functions as a key coastal system linking fisheries productivity and ecosystem restoration. Pak Panang Bay serves as a critical deltaic ecosystem for food security and flood protection, supporting integrated resource management under national and royal initiatives. Samut Prakan Province, though urbanized, maintains vital wetlands that act as natural buffers for flood regulation and carbon storage, particularly in Bang Pu and Khlong Dan. Don Hoi Lot, designated as a Ramsar Site, stands out for its global significance in biodiversity conservation, blue carbon storage, and community-based coastal resilience.

All sites are legally protected under designations such as National Reserved Forests, Coastal Wetlands managed by DMCR, or Ramsar Sites, covering extensive areas of mangrove forests, tidal flats, and estuarine habitats. Together, they form a foundation for Thailand's coastal sustainability framework, ensuring ecosystem health, livelihood support, and climate adaptation. (Table 3).

Table 3. Mangroves and wetland areas in Thailand (Gulf of Thailand): Social and use information showing significance/national importance and protection status

Name of area	Significance/national importance	Protection status
MG1: Welu River Estuary	The Welu River Estuary is nationally significant as a key coastal wetland supporting Thailand's goals in sustainable coastal management, blue economy development, and climate resilience. It is recognized in national and regional master plans—such as the Strategic Action Programme for the South China Sea (SAP) and Thailand's National Strategy 2018–2037—as a priority area for ecosystem-based management and mangrove conservation. The estuary contributes to national objectives in fisheries productivity, aquaculture, carbon sequestration, and biodiversity protection, while providing vital ecosystem services and livelihoods for coastal communities. Its sustainable use aligns with Thailand's commitments to climate adaptation, blue carbon initiatives, and inclusive coastal development.	It is designated as a National Reserved Forest. The total wetland area is approximately 20,000 hectares. The mangrove area is about 7,206 hectares (as of 2009).
MG2: Bandon Bay	Bandon Bay represents a nationally important coastal landscape where economic development and natural ecosystems are deeply interlinked. It contributes	It is recognized as a National Coastal Wetland managed

Name of area	Significance/national importance	Protection status
	significantly to Thailand’s blue economy, fisheries productivity, and climate-change mitigation efforts through its rich mangrove, seagrass, and tidal-flat systems. The bay’s sustainable management and restoration are therefore essential to achieving national goals in coastal resilience, carbon neutrality, and inclusive local development.	under the Department of Marine and Coastal Resources (DMCR). The total coastal and wetland area is approximately 100,000 hectares. The mangrove forests cover about 17,000 hectares, while the tidal flats extend across roughly 50,000 hectares.
MG3: Pak Panang Bay	Pak Panang Bay is a nationally important estuarine and coastal ecosystem supporting Thailand’s blue economy, food security, and climate resilience goals. It contributes substantially to fisheries productivity, aquaculture, mangrove restoration, and blue carbon sequestration, while providing natural defenses against flooding and erosion. The bay’s strategic location within the Pak Phanang River Delta Development Project and Royal Initiatives highlights its role as a model for sustainable coastal livelihood development and integrated resource management.	It is designated as a Coastal Wetland and National Reserved Forest Area managed under the Department of Marine and Coastal Resources (DMCR). The total coastal and wetland area is approximately 60,000 hectares. The mangrove forests cover about 17,500 hectares, while the tidal flats extend across roughly 25,000 hectares.

Name of area	Significance/national importance	Protection status
MG: Samut Prakan Province	Samut Prakan Province holds national importance as both an industrial–economic hub and a coastal ecological buffer within the Upper Gulf of Thailand. The province contributes to fisheries productivity, port logistics, and carbon sequestration, while small remaining wetlands and mangroves provide ecosystem services, flood regulation, and educational value. Sustainable management of these habitats—especially in Bang Pu and Khlong Dan—is critical to achieving Thailand's coastal resilience, blue carbon, and sustainable urban development goals.	It is designated as a National Reserved Forest and DMCR Coastal Management Area. The total coastal and wetland area is approximately 20,000 hectares. The mangrove forests cover about 1,500 hectares, while the tidal flats extend across roughly 3,000 hectares.
WL1: Don Hoi Lot	Don Hoi Lot represents a nationally and globally important coastal wetland, sustaining both biodiversity conservation and community livelihoods. Its Ramsar designation underscores its ecological and economic value as a model site for ecosystem-based coastal management. The area supports fisheries productivity, ecotourism, and blue carbon storage, while contributing to Thailand's commitments under international wetland and climate agreements. Sustainable management of Don Hoi Lot is therefore crucial for maintaining food security, coastal resilience, and inclusive local development.	It is designated as a Ramsar Site (No. 1099) and part of a National Reserved Forest under the Department of Marine and Coastal Resources (DMCR) and Department of National Parks, Wildlife and Plant Conservation (DNP). The total wetland area is approximately 8,500 hectares. The mangrove forests

Name of area	Significance/national importance	Protection status
		cover about 1,200 hectares, while the tidal flats extend across roughly 6,000 hectares.

- **Biological data**

Present status and natural/managed

Based on the compiled figures, mangrove condition across the five focal sites shows clear variation in both extent and management balance. Bandon Bay supports the largest mangrove area (255.70 km²) and retains a ~63–77.5% natural share, despite substantial shellfish mariculture (~37–22.5% managed). Welu River Estuary contains 72.06 km² of mangroves and exhibits the highest managed fraction among the estuaries with estimates (≤47.3%), yet still maintains ≥52.7% natural cover through broad Rhizophora–Avicennia belts. Pak Phanang Bay holds 90.00 km² of mangroves and remains predominantly natural (≥65.0%), although hydrological control and aquaculture create managed shore segments (≤35.0%). Don Hoi Lot has a smaller mapped mangrove extent (29.19 km²) within a much larger Ramsar site but is functionally 100% natural in the demonstration area, dominated by intertidal flats with fringing mangroves. For the Samut Prakan (Bang Pu) focal area (33.74 km² of mangroves), an official natural/managed percentage is not reported; the highly urban setting indicates active protection of small remnant patches. Collectively, these results indicate strong residual natural capital at Pak Phanang, Don Hoi Lot, and much of Bandon Bay, while Welu and the urbanized Samut Prakan coast underscore the need for targeted co-management, restoration, and pollution control to bolster ecological integrity (Table 4).

Table 4. Mangroves and wetland areas in Thailand (Gulf of Thailand): Biological data showing present status and natural/managed

Name of area	Present status (km^2)	Natural/Managed
MG1: Welu River Estuary	72.06	≥ 52.7 % / ≤ 47.3 %
MG2: Bandon Bay	255.70	≈ 63–77.5 % / ≈ 37–22.5 %
MG3: Pak Panang Bay	90.00	≥ 65.0 % / ≤ 35.0 %

Name of area	Present status (km^2)	Natural/Managed
MG: Samut Prakan Province	33.74	-
WL1: Don Hoi Lot	29.19	100/0

Mangrove diversity, density and dominant species

An assessment of the five focal sites shows clear spatial variation in recorded species richness and floristic composition. Khlong Dan (Samut Prakan) exhibits the highest documented diversity (30 species), followed by the Welu River Estuary (26 species) and Bandon Bay (24 species). Bang Pu Nature Education Centre supports 17 species, while Pak Phanang Bay and Don Hoi Lot lack complete species counts in the present table.

Across sites, the most frequently recorded dominants are *Rhizophora apiculata* and *R. mucronata*, with *Avicennia alba* also recurring—underscoring the ecological importance of Rhizophoraceae and Avicenniaceae in structuring these mangrove communities. Site-specific characteristic taxa further enrich the assemblages: *Excoecaria agallocha* and *Lumnitzera racemosa* at Welu; *Sonneratia caseolaris* at Pak Phanang; and *Bruguiera cylindrica, B. gymnorhiza*, and *Ceriops tagal* at Khlong Dan. Stand-density data (trees km^{-2}) were not reported for the sites in this compilation, highlighting a monitoring gap.

Overall, the pattern points to high but heterogeneous mangrove diversity across the Gulf of Thailand sites, dominated by Rhizophora–Avicennia frameworks with locally distinctive Bruguiera, Ceriops, Lumnitzera, and Sonneratia elements. Filling the density data gap and standardising plot surveys would strengthen comparisons and support site-specific conservation and restoration planning (Table 5).

Table 5. Mangroves and wetland areas in Thailand (Gulf of Thailand): Biological data showing mangrove diversity, density and dominant species

Name of area	Mangrove diversity	Density Trees per km^2	Dominant species
MG1: Welu River Estuary	26 Species	**-**	- *Rhizophora apiculata* - *Excoecaria agallocha* - *Lumnitzera racemosa*
MG2: Bandon Bay	24 Species	**-**	- *Rhizophora apiculata* - *Rhizophora mucronata* - *Avicennia alba*
MG3: Pak Panang Bay	**-**	**-**	- *Avicennia alba*

Name of area	Mangrove diversity	Density Trees per km^2	Dominant species
			- *Sonneratia caseolaris* - *Rhizophora apiculata*
MG: Samut Prakan Province	***Khlong Dan subdistrict*** 30 species ***Bangpu Nature Education Centre*** 17 species	-	***Khlong Dan subdistrict*** - *Bruguiera cylindrica* - *Bruguiera gymnorrhiza* - *Ceriops tagal* - *Rhizophora apiculate* - *Rhizophora mucronata* ***Bangpu Nature Education Centre*** - *Rhizophora apiculata* - *Rhizophora mucronata* - *Bruguiera* sp.
WL1: Don Hoi Lot	-	-	- *Rhizophora apiculate* - *Rhizophora mucronata*

Migrating species, SCS endemic species, endangered of threatened species (IUCN), and source & sink of larvae

The assessment of migratory and threatened species across the five focal mangrove and wetland sites in the Gulf of Thailand reveals distinct ecological roles and conservation values. Migratory birds utilize all sites seasonally*:* *Charadrius mongolus* and *Lanius cristatus* are common at Welu River Estuary; *Xenus cinereus* and *Irrawaddy dolphin* (Orcaella brevirostris) occur in Bandon Bay; *Numenius arquata* and *foraging dugongs* are reported near Pak Panang Bay; and Don Hoi Lot supports large flocks of East Asian–Australasian Flyway birds such as Sternula albifrons, Chlidonias hybrida, and Ardea cinerea.

Species of conservation concern are concentrated at specific sites. Welu River Estuary hosts *Bruguiera hainesii* and *Sonneratia griffithii* (CR) and *Heritiera fomes* (EN); Bandon Bay supports *Calidris tenuirostris* (EN), *Halcyon pileata*, *Rhyticeros subruficollis*, and *Egretta eulophotes* (VU). Don Hoi Lot harbors Solen regularis, a South China Sea (SCS) regional endemic, and several threatened species in nearby waters, including *Aythya baeri* (CR) and *Pangasianodon hypophthalmus* (EN).

Functionally, Don Hoi Lot serves as a major source-sink system for larvae and juveniles of estuarine fauna, with high connectivity between the Mae Klong estuary and intertidal mudflats. Across the region, these findings highlight the ecological connectivity of Thailand’s coastal wetlands—supporting migratory routes, endemic biodiversity, and recruitment pathways essential for maintaining ecosystem productivity and resilience. (Table 6)

Table 6. Mangroves and wetland areas in Thailand (Gulf of Thailand): Biological data showing seagrass diversity and composition, migrating species, SCS endemic species, endangered of threatened species (IUCN), and source & sink of larvae

<table>
<tr><th>Name of area</th><th>Migrating species</th><th>SCS Endemic species</th><th>Endangered of threatened species (IUCN)</th><th>Source & sink of larvae</th></tr>
<tr><td>MG1: Welu River Estuary</td><td>- Charadrius mongolus
- Lanius cristatus</td><td>-</td><td rowspan="4">Plant species:
Critically Endangered
- Bruguiera hainesii
- Sonneratia griffithii
Endangered
- Heritiera fomes

Birds:
Endangered
- Calidris tenuirostris
Vulnerable
- Halcyon pileate
- Rhyticeros subruficollis
- Egretta eulophotes</td><td>-</td></tr>
<tr><td>MG2: Bandon Bay</td><td>- Xenus cinereus

Mammals:
Irrawaddy dolphin – seasonal coastal movements</td><td></td><td></td></tr>
<tr><td>MG3: Pak Panang Bay</td><td>Mammals:
Dugong in adjacent seagrass areas – seasonal foraging</td><td></td><td></td></tr>
<tr><td>MG: Samut Prakan Province</td><td>- Numenius Arquata

Mammals:
Irrawaddy dolphin (Orcaella brevirostris) – partial</td><td>-</td><td></td></tr>
</table>

	seasonal movement			
WL1: Don Hoi Lot	Used by East Asian–Australasian Flyway birds, e.g., Little Tern (*Sternula albifrons*), Whiskered Tern (*Chlidonias hybrida*), Grey Heron (*Ardea cinerea*), plus seasonal shorebirds using the mudflats as feeding/roosting habitat.	Razor clam *Solen regularis* (regional endemic/flagship of the site).	Recorded/threat-noted species include Baer's Pochard (Aythya baeri, CR), Striped Catfish (Pangasianodon hypophthalmus, EN), and King Cobra (Ophiophagus hannah, VU) in the wider site context.	Functions as a nursery and larval exchange area for coastal/estuarine fauna in the Upper Gulf; decapod larvae and bivalve recruits are commonly recorded in the Mae Klong estuary–mudflat system, indicating source–sink connectivity.

- **Stress-pressure information**

  Intrinsic/internal sources of change

The assessment of intrinsic drivers of ecological change across mangrove and wetland ecosystems in the Gulf of Thailand reveals that both natural and human-induced internal processes shape the long-term resilience and productivity of these coastal systems. Key natural drivers include tidal dynamics, sediment transport, salinity fluctuations, and seasonal storm events, which continuously influence shoreline stability, sediment deposition, and nutrient cycling. These processes govern habitat regeneration, seedling recruitment, and species composition within mangrove and tidal flat ecosystems. In parallel, human-related internal factors—such as population growth, aquaculture expansion, and mangrove resource use—intensify habitat degradation and alter ecosystem balance. For instance, Samut Prakan Province experiences the combined effects of urbanization, land reclamation, and coastal erosion, while Don Hoi Lot is affected by hydro-sedimentary shifts and shellfish harvesting that disturb the mudflat–mangrove interface. Collectively, these internal pressures reflect the dynamic yet vulnerable nature of Thailand's coastal wetlands, emphasizing the need for adaptive and integrated ecosystem management that accommodates natural variability and human activity to sustain long-term ecological resilience. (Table 7)

Table 7. Mangroves and wetland areas in Thailand (Gulf of Thailand): Stress-pressure information showing intrinsic/internal sources of change

Name of area	Intrinsic/internal sources of change
MG1: Welu River Estuary	The Welu River Estuary is influenced by both human and natural internal factors. Population growth, aquaculture expansion, and mangrove resource use have led to habitat degradation and water quality decline. Natural processes such as heavy storm impacts, marine flooding, sediment fluctuation, and coastal erosion further alter estuarine morphology and ecosystem balance. Together, these forces drive continuous ecological change and affect the long-term resilience of the estuary.
MG2: Bandon Bay	Bandon Bay is influenced by both human and natural internal factors. The expansion of aquaculture farms, coastal fisheries, and urban development has led to habitat degradation, nutrient enrichment, and declining water quality in some nearshore areas. Overexploitation of mangrove resources and conversion of intertidal zones for shrimp and oyster farming have further altered natural habitats. Meanwhile, natural processes such as monsoon storms, tidal surges, sediment dynamics, and coastal erosion continually reshape the bay's morphology and influence salinity and sediment distribution. Together, these human and natural forces drive ongoing ecological change, affecting the long-term resilience and productivity of Bandon Bay's coastal and marine ecosystems.
MG3: Pak Panang Bay	Pak Panang Bay is influenced by both human and natural internal factors. Expansion of shrimp farming, coastal fisheries, and agricultural runoff has contributed to habitat alteration, nutrient loading, and water quality decline in the bay. Mangrove degradation from land conversion and overexploitation of coastal resources further disrupts the ecological balance of the estuarine system. Meanwhile, natural processes such as seasonal monsoon storms, tidal flooding, sediment fluctuation, and shoreline erosion continuously reshape the deltaic landscape, affecting salinity regimes and sediment deposition. The combined influence of these human and natural drivers results in ongoing ecological change, impacting the resilience, productivity, and ecosystem services of Pak Panang Bay.
MG: Samut Prakan Province	Samut Prakan Province is shaped by both human and natural internal factors. Rapid urbanization, industrial growth, and land reclamation have led to significant loss of wetlands and mangrove habitats, reducing ecosystem health and water quality. Meanwhile, tidal flooding, sediment imbalance, and coastal erosion naturally reshape the shoreline and estuarine system. Together, these pressures cause continuous ecological

Name of area	Intrinsic/internal sources of change
	change and diminish the resilience of the coastal environment.
WL1: Don Hoi Lot	Don Hoi Lot is influenced by both human and natural internal factors. Shellfish harvesting, coastal tourism, and community activities have caused localized habitat disturbance and water quality decline, particularly on tidal flats. Overuse of coastal resources and mangrove clearance for access and small-scale aquaculture have also affected ecosystem integrity. Meanwhile, natural processes such as tidal fluctuations, marine flooding, sediment movement, and coastal erosion continually reshape the mudflat landscape and influence habitat distribution. Together, these human and natural factors drive ongoing ecological changes, affecting the long-term stability and resilience of the Don Hoi Lot wetland ecosystem.

Extrinsic/external sources of change

The assessment of extrinsic or external sources of change affecting mangrove and wetland ecosystems along the Gulf of Thailand reveals a wide spectrum of anthropogenic pressures linked to aquaculture expansion, urban development, and upstream watershed modifications. In areas such as Welu River Estuary and Bandon Bay, large-scale conversion of mangroves into shrimp ponds, combined with agricultural irrigation schemes and canal construction, has reduced freshwater inflows and altered salinity regimes. Long-term mangrove decline is evident in Pak Panang Bay, where sluice gates, flood dikes, and irrigation systems have disrupted tidal exchange and sediment dynamics. Samut Prakan Province illustrates the severe cumulative impacts of urbanization, port and industrial expansion, and wastewater discharge, compounded by multiple dams and diversions within the Chao Phraya Basin. Don Hoi Lot further highlights the pressures of pollution, aquaculture, overharvesting, and invasive species, which exacerbate ecological vulnerability. Collectively, these external drivers demonstrate how human activities at both local and watershed scales continue to undermine the resilience of mangrove and wetland ecosystems, emphasizing the urgent need for integrated, catchment-to-coast management strategies. (Table 8)

Table 8. Mangroves and wetland areas in Thailand (Gulf of Thailand): Stress-pressure information showing extrinsic/external sources of change

Name of area	Extrinsic/external sources of change
MG1: Welu River Estuary	Mangrove loss of approximately 60% occurred between the 1970s and 2009, followed by slow recovery after 2010 through community-led restoration projects. Large-scale conversion of mangroves into shrimp ponds and coastal tourism facilities was the primary cause of this severe decline. In addition, agricultural expansion and the construction of irrigation canals reduced freshwater inflow and altered estuarine salinity and turbidity.
MG2: Bandon Bay	Continuous conversion of mangroves into aquaculture occurred during the 2010s, while partial recovery has been observed since the mid-2010s through rehabilitation projects. Extensive losses from shrimp farming prompted the initiation of the “Reversing Environmental Damage – Bandon Bay” project to restore degraded mangrove ecosystems. In addition, the Tapi River Basin is regulated by dams and irrigation schemes, which have altered freshwater discharge and sediment delivery to the bay.
MG3: Pak Panang Bay	Mangroves have experienced a long-term decline, with fragmented reforestation projects implemented since the early 2000s. Mangrove clearing has reduced fish diversity and impaired ecosystem functions, while afforestation attempts on intertidal mudflats have been recorded. Furthermore, the river basin has been modified by sluice gates, flood dikes, and irrigation systems, which have reduced tidal exchange and sediment flow and altered the salinity balance.
MG: Samut Prakan Province	There has been severe historical loss of mangroves, with only minimal remnants remaining after 2010 despite replanting efforts. Urbanization, land reclamation, and the expansion of ports and industries have driven large-scale destruction. In addition, the Chao Phraya Basin is regulated by multiple dams and diversions, and heavy urban wastewater inflows have further compounded the stress on the remaining mangroves.
WL1: Don Hoi Lot	The area faces severe pressures from pollution, coastal development, aquaculture, overharvesting, invasive species, and altered freshwater-sediment flows, highlighting its ecological vulnerability and the need for integrated management.

Rates of change and historical review

A review of historical trends and rates of change in mangrove and wetland areas along the Gulf of Thailand reveals considerable spatial variation in ecosystem trajectories. At the Welu River Estuary, mangrove cover declined by nearly 60% between the 2010 and 2024 due to shrimp farming, coastal development, and agriculture, with only partial recovery achieved through community-led reforestation since 2010. In Bandon Bay, widespread conversion to aquaculture during the 2010s has resulted in only limited recovery despite rehabilitation projects, while upstream dams and irrigation continue to alter freshwater and sediment regimes. By contrast, Pak Panang Bay has shown slight increases in mangrove cover attributed to replanting initiatives, while Samut Prakan Province experienced a modest decline of around 1–2% due to land conversion and erosion. Don Hoi Lot remains highly vulnerable, with external pressures from pollution, coastal development, overharvesting, invasive species, and disrupted freshwater inflows compounding ecological stress. Collectively, these findings highlight both the long-term pressures driving mangrove degradation and the role of targeted restoration in fostering localized recovery and resilience. (Table 9)

Table 9. Mangroves and wetland areas in Thailand (Gulf of Thailand): Stress-pressure information showing rates of change and historical review

Name of area	Rates of change, historical review
MG1: Welu River Estuary	Mangrove cover declined by ~60% between the 2010 and 2024 due to shrimp farming, tourism development, and agriculture, with only partial recovery observed since 2010 through community-led reforestation.
MG2: Bandon Bay	Converted to aquaculture during the 2010s, the area has shown only limited recovery since the mid-2010s. Losses from shrimp farming prompted the "Reversing Environmental Damage – Bandon Bay" project, while upstream dams and irrigation continue to alter freshwater and sediment flows.
MG3: Pak Panang Bay	Slight increase in mangrove covers due to replanting projects.
MG: Samut Prakan Province	Estimated decrease of around 1–2% from land conversion and erosion.
WL1: Don Hoi Lot	External pressures include pollution, coastal development, overharvesting, and invasive species, compounded by altered freshwater inflows, underscoring its ecological vulnerability.

Social and Economic Drivers and Economic Valuation of Coastal Ecosystems

This review summarizes findings from five key coastal study sites in Thailand—Welu River Estuary, Bandon Bay, Pak Panang Bay, Samut Prakan Province, and Don Hoi Lot—focusing on social and economic drivers of environmental change and the economic valuation of coastal ecosystems following the framework of Barbier (1997).

Across all sites, major drivers of change include population growth, aquaculture expansion, industrial development, and tourism, leading to habitat alteration, water quality decline, and reduced ecosystem resilience. Despite these pressures, the coastal ecosystems provide high economic value through direct use services (such as fisheries, aquaculture, and mangrove products) and indirect use services (including coastal protection, nutrient cycling, and carbon sequestration).

Overall, the total annual economic value of these ecosystems is estimated to be between US$17 and $32 million per area, reflecting their vital contribution to local livelihoods, fisheries productivity, and national blue economy and climate resilience goals. The following table presents a comparative overview of all study areas, linking social and economic drivers with ecosystem service values to support sustainable coastal resource management and policy planning (Table 10).

Table 10. Social and Economic Drivers and Economic Valuation of Coastal Ecosystems

Name of area	Social and economic drivers of change in environmental state	Economic valuation (based on Barbier, E.B. 1997)
MG1: Welu River Estuary	The environmental condition of the Welu River Estuary is driven by both social and economic pressures. Population growth and labor migration have increased local demand for coastal resources, while aquaculture expansion and commercial fisheries have transformed traditional livelihoods into more intensive practices. Rising income opportunities from shrimp and oyster farming have led to mangrove and intertidal land conversion, contributing to water pollution and habitat loss. Meanwhile, domestic seafood demand and export markets continue to intensify resource extraction. Management of the estuary under the Department of Marine and Coastal Resources (DMCR) as a National Reserved Forest has promoted community-based conservation and mangrove restoration, yet enforcement challenges and conflicting land	The Welu River Estuary provides substantial economic value through both direct and indirect ecosystem services. The estuary’s direct use values, such as fisheries, aquaculture, and mangrove products, are estimated at around US$6–7 million per year. Indirect use values, including coastal protection, nutrient cycling, and carbon sequestration, contribute an additional US$10–15 million per year, with mangrove carbon storage alone valued at approximately US$130–185 million in total stock. When combined, the overall annual economic value of the Welu River Estuary is estimated at

	uses persist. Overall, the combination of economic development, population dynamics, and evolving management regimes has reshaped the estuary's environmental state, reduced ecosystem resilience and altered its natural balance.	US$18–23 million, highlighting its importance for local livelihoods, biodiversity conservation, and national blue carbon objectives.
MG2: Bandon Bay	The environmental state of Bandon Bay is shaped by significant social and economic drivers. The bay supports a dense coastal population engaged primarily in fisheries, aquaculture, and seafood processing, which form the economic backbone of Surat Thani Province. The expansion of shrimp, crab, and oyster farming, along with growing seafood demand from domestic and export markets, has led to extensive conversion of intertidal zones and mangrove areas. Population growth and in-migration of aquaculture labor have further intensified coastal resource use. At the same time, nutrient loading and sediment accumulation from aquaculture and land-based runoff have degraded water quality, while infrastructure development around the bay has altered natural hydrology. Management of Bandon Bay falls under the Department of Marine and Coastal Resources (DMCR) through provincial coastal management frameworks and community-based initiatives. However, enforcement challenges and competing economic priorities continue to pressure the ecosystem. Overall, rapid aquaculture expansion,	The Bandon Bay ecosystem provides high economic value through both direct and indirect uses. The bay's direct use values, including fisheries, aquaculture (shrimp, crab, and oyster farming), and mangrove resource utilization, are estimated at around US$10–12 million per year. The indirect use values, such as coastal protection, nutrient cycling, and carbon sequestration from mangrove ecosystems, contribute an additional US$15–20 million annually. In total, the annual economic value of Bandon Bay is estimated at approximately US$25–32 million, with mangrove forests also storing significant blue carbon value exceeding US$200 million. These values highlight the bay's importance in supporting fisheries productivity, coastal livelihoods, and Thailand's blue economy and climate resilience

	population dynamics, and high market demand remain the key social and economic forces driving habitat transformation, declining water quality, and reduced ecological resilience in Bandon Bay.	goals.
MG3: Pak Panang Bay	The environmental state of Pak Panang Bay is driven by multiple social and economic factors linked to population growth, livelihood dependence, and resource use. The bay supports a dense rural population whose main livelihoods include shrimp farming, coastal fisheries, and agriculture within the Pak Phanang River Delta. The rapid expansion of aquaculture—particularly shrimp ponds—has resulted in widespread mangrove clearance, land conversion, and increased nutrient discharge, contributing to habitat loss and declining water quality. High market demand for seafood at both local and national levels has intensified fishing and farming pressure, while agricultural runoff from upstream areas adds sediment and pollutants to the bay. Income diversification has also shifted traditional livelihoods toward more commercialized, resource-intensive activities. On the governance side, the bay falls under the Department of Marine and Coastal Resources (DMCR) and the Royal Development Study Centre, which promote integrated delta management and mangrove restoration, yet enforcement and land-use conflicts persist.	The Pak Panang Bay ecosystem provides significant economic value through both direct and indirect uses. The direct use values, including fisheries, aquaculture (especially shrimp and crab farming), and mangrove resources, are estimated at approximately US$8–10 million per year. The indirect use values, such as coastal protection, nutrient cycling, and carbon sequestration by mangrove ecosystems, contribute an additional US$12–15 million annually. Altogether, the annual economic value of Pak Panang Bay is estimated at around US$20–25 million, with mangrove forests also representing a large blue carbon stock valued at over US$150 million. These values highlight the bay's vital role in supporting local livelihoods, fisheries productivity, and Thailand's blue economy and climate adaptation

	Overall, population pressure, aquaculture expansion, and agricultural intensification, combined with weak enforcement and overlapping management, remain the major social and economic drivers of environmental degradation and reduced ecosystem resilience in Pak Panang Bay.	objectives.
MG: Samut Prakan Province	The environmental condition of Samut Prakan Province is strongly influenced by social and economic drivers associated with rapid urbanization, industrialization, and coastal development. The province's proximity to Bangkok has made it a hub for manufacturing, logistics, and port activities, leading to extensive land reclamation and the loss of natural wetlands and mangrove areas. The expansion of industrial estates, residential zones, and infrastructure has increased wastewater discharge, sedimentation, and pollution in the lower Chao Phraya River estuary. Population density in Samut Prakan—over 1.3 million people—has grown steadily, driven by migration for industrial and service-sector employment. This population pressure, combined with rising demand for space and resources, has intensified coastal modification and environmental degradation. Traditional livelihoods such as small-scale fishing and aquaculture persist but are declining due to pollution and limited resource access. The province's coastal and estuarine	The Samut Prakan coastal zone provides considerable economic value primarily through direct use services such as fisheries, aquaculture, port activities, and industrial water use, estimated at approximately US$12–15 million per year. Despite being heavily urbanized, the remaining mangrove areas contribute significant indirect values in the form of coastal protection, flood regulation, and carbon sequestration, valued at around US$8–10 million annually. Together, the total annual economic value of Samut Prakan's coastal and estuarine ecosystems is estimated at about US$20–25 million, with the small remaining mangrove forests storing blue carbon worth more than US$100 million. These values underline the importance of conserving the province's remaining natural

	management falls under the Department of Marine and Coastal Resources (DMCR), which supports community-based mangrove restoration and eco-education projects in areas like Bang Pu and Khlong Dan. However, enforcement challenges and competing land-use priorities between industrial growth and ecosystem conservation remain significant. Overall, urban expansion, population pressure, and industrial demand are the key social and economic forces driving habitat loss, pollution, and reduced ecological resilience in Samut Prakan's coastal zone.	habitats, which continue to provide ecosystem services, coastal resilience, and socio-economic benefits despite intense urban and industrial development.
WL1: Don Hoi Lot	The environmental condition of Don Hoi Lot is influenced by both social and economic factors related to resource use, tourism, and local livelihoods. The area's economy depends heavily on shellfish harvesting, especially blood cockles (*Anadara granosa*), which are collected for both household consumption and commercial trade. This high demand, along with growing tourism activities, has increased human disturbance on mudflats and nearby mangrove areas. Population growth and seasonal migration for fisheries-related work have also heightened pressure on coastal resources and waste generation. At the same time, the development of seafood markets, tourism facilities, and transport infrastructure has altered land use and water circulation near the estuary. The	The Don Hoi Lot Wetland provides high economic value through its diverse ecosystem services. The direct use values, including shellfish harvesting, small-scale fisheries, and mangrove resource utilization, are estimated at around US$7–9 million per year. The indirect use values, such as coastal protection, sediment stabilization, nutrient cycling, and carbon sequestration from mangrove ecosystems, contribute an additional US$10–12 million annually. Altogether, the total annual economic value of Don Hoi Lot is estimated at approximately US$17–21 million,

	site is managed as a Ramsar Site and National Reserved Forest under the Department of Marine and Coastal Resources (DMCR) and the Department of National Parks (DNP), which promote sustainable shellfish harvesting, mangrove restoration, and ecotourism management. However, challenges remain due to unregulated harvesting, tourist crowding, and limited waste control. Overall, intensive resource extraction, tourism expansion, and population-driven demand are the main social and economic drivers of environmental change and habitat stress in Don Hoi Lot, affecting the long-term sustainability of this nationally and globally important wetland ecosystem.	with mangrove and mudflat ecosystems also providing significant blue carbon storage worth over US$120 million. These values highlight the site's critical role in sustaining fisheries productivity, community livelihoods, and Thailand's commitments to blue economy and wetland conservation goals.

Economic Valuation of Coastal and Estuarine Ecosystem Services

This review provides an overall summary of the economic values of coastal and estuarine ecosystems across the five study areas. It focuses on two key aspects: direct use values, which include the benefits gained from natural resource utilization such as fisheries, aquaculture, timber, and charcoal; and indirect use values, which encompass ecological services such as carbon sequestration, nursery functions for marine species, and ecotourism. These combined values highlight the essential role of Thailand's coastal ecosystems in sustaining local livelihoods, food security, and climate resilience, while contributing significantly to the national blue economy and sustainable development goals. The following table presents a comparative overview of the estimated direct and indirect use values for each study site (Table 11).

Table 11. Economic Valuation of Coastal and Estuarine Ecosystem Services: Direct and Indirect Use Values

Name of area	Values of direct use	Values of indirect use
MG1: Welu River Estuary	The Welu River Estuary provides high direct use values from its natural resources, particularly mangrove timber, charcoal, and living marine resources. Sustainable harvesting of mangrove	The Welu River Estuary provides considerable indirect use values that contribute to ecological stability and local economic benefits. The mangrove forests act as major carbon

	wood generates about US$0.7–1.1 million per year, while fisheries and aquaculture activities contribute approximately US$5.8–7.2 million per year. Altogether, the total direct use value is estimated at US$6.5–8.0 million annually, emphasizing the estuary's vital role in supporting local livelihoods, small-scale economies, and food security in the coastal zone.	sinks, storing about 720,000–1,000,000 tonnes of carbon, valued at roughly US$9–13 million per year in blue carbon benefits. The estuary also serves as a critical nursery area for shrimp, crabs, and fish, supporting the productivity of surrounding fisheries with an estimated value of US$1–1.5 million per year. In addition, ecotourism and educational activities, such as mangrove trails and community-based conservation tours, provide around US$0.3–0.5 million annually. Overall, the total indirect use value of the Welu River Estuary is estimated at US$10–15 million per year, highlighting its importance for carbon storage, fisheries support, and sustainable community development.
MG2: Bandon Bay	The Bandon Bay ecosystem generates high direct use values from its coastal and marine resources. The bay supports extensive fisheries and aquaculture, particularly shrimp, crab, and oyster farming, which are estimated to contribute US$9–11 million per year. In addition, mangrove forests along the bay provide timber, fuelwood, and charcoal, valued at approximately US$1–1.5 million annually. Combined, the total direct use value of Bandon Bay is estimated at US$10–12 million per year, reflecting its crucial role in	The Bandon Bay ecosystem provides high indirect use values through key ecological functions that support both biodiversity and local economies. The extensive mangrove forests act as vital carbon sinks, storing an estimated 1.5–2.0 million tonnes of carbon, valued at around US$10–14 million per year. The bay also serves as a major nursery ground for shrimp, crab, and fish populations, contributing approximately US$2–3 million annually to coastal fisheries productivity. In addition, emerging ecotourism and

	sustaining local economies, livelihoods, and Thailand's coastal fisheries productivity.	educational activities associated with mangrove and aquaculture learning sites generate about US$0.5–0.8 million per year. Altogether, the total indirect use value of Bandon Bay is estimated at US$13–18 million per year, underscoring its importance in carbon sequestration, fisheries support, and sustainable coastal development within the Gulf of Thailand.
MG3: Pak Panang Bay	The Pak Panang Bay ecosystem provides significant direct use values through its rich natural and aquatic resources. The bay supports extensive fisheries and aquaculture, especially shrimp and crab farming, which contribute an estimated US$7–9 million per year to the local economy. In addition, mangrove forests surrounding the bay supply timber, charcoal, and fuelwood, valued at around US$1–1.2 million annually. Altogether, the total direct use value of Pak Panang Bay is estimated at approximately US$8–10 million per year, underscoring its importance in sustaining coastal livelihoods, food production, and regional economic stability.	The Pak Panang Bay ecosystem provides substantial indirect use values through its ecological and climate-regulating functions. The extensive mangrove forests act as major carbon sinks, storing an estimated 1.2–1.5 million tonnes of carbon, valued at approximately US$8–11 million per year in blue carbon benefits. The bay also functions as a crucial nursery ground for shrimp, crab, and finfish species, supporting local and regional fisheries with an estimated value of US$2–2.5 million annually. In addition, ecotourism and environmental education activities related to mangrove restoration and delta conservation generate about US$0.5–0.7 million per year. Overall, the total indirect use value of Pak Panang Bay is estimated at US$10–14 million per

		year, emphasizing its vital role in carbon sequestration, fisheries productivity, and sustainable coastal livelihoods.
MG: Samut Prakan Province	The Samut Prakan coastal zone provides notable direct use values from its remaining natural and economic resources. Despite rapid urbanization, the province still supports small-scale fisheries and aquaculture, contributing approximately US$10–12 million per year through fish, shrimp, and crab production. The limited mangrove areas in Bang Pu and Khlong Dan supply timber, fuelwood, and charcoal, valued at around US$1–1.3 million annually. Altogether, the total direct use value of Samut Prakan's coastal ecosystems is estimated at US$12–15 million per year, reflecting their continued importance in supporting local livelihoods, seafood production, and coastal community resilience amid industrial and urban expansion.	The Samut Prakan coastal zone provides significant indirect use values that support both ecological stability and human well-being within a heavily urbanized environment. The remaining mangrove forests along areas such as Bang Pu and Khlong Dan play a vital role in carbon sequestration, storing around 250,000–300,000 tonnes of carbon, valued at approximately US$2–3 million per year in blue carbon benefits. These mangroves and estuarine wetlands also function as nursery grounds for shrimp, crabs, and small fish, sustaining nearby fisheries and valued at about US$1–1.5 million annually. Furthermore, ecotourism and environmental education activities, including birdwatching and mangrove learning centers in Bang Pu, generate an estimated US$0.5 million per year. In total, the indirect use value of Samut Prakan's coastal ecosystems is estimated at US$3.5–5 million per year, highlighting their essential contribution to carbon storage, biodiversity support, and public environmental awareness amid ongoing urban and industrial

		expansion.
WL1: Don Hoi Lot	The Don Hoi Lot Wetland provides high direct use values derived from its abundant coastal and estuarine resources. The area's main economic activity—shellfish harvesting, particularly blood cockles (Anadara granosa) and other bivalves—generates an estimated US$6–8 million per year. In addition, small-scale fisheries and mangrove resource use (timber, charcoal, and fuelwood) contribute about US$1–1.2 million annually. Combined, the total direct use value of Don Hoi Lot is estimated at approximately US$7–9 million per year, underscoring its importance as a source of income, food security, and coastal livelihoods for local communities, while also supporting Thailand's sustainable fisheries and blue economy objectives.	The Don Hoi Lot Wetland provides high indirect use values through its ecological, climate, and socio-economic functions. The area's mangrove forests and tidal flats play an important role in carbon sequestration, storing approximately 400,000–500,000 tonnes of carbon, with an estimated value of US$3–4 million per year in blue carbon benefits. The extensive mudflat ecosystem also serves as a crucial nursery ground for shrimp, crabs, and mollusks, supporting fisheries valued at about US$1–1.5 million annually. Moreover, ecotourism and environmental education, such as shellfish observation and mangrove learning programs, generate an additional US$0.5–0.8 million per year. Altogether, the total indirect use value of Don Hoi Lot is estimated at US$5–6 million per year, highlighting its essential role in carbon storage, fisheries sustainability, and nature-based tourism within Thailand's upper Gulf region.

Environmental Service Values and Restoration Investment in Coastal and Estuarine Ecosystems

This review presents a comparative overview of the environmental service values and restoration investments across five key coastal and estuarine areas—Welu River Estuary, Bandon Bay, Pak Panang Bay, Samut Prakan Province, and Don Hoi Lot. These ecosystems provide crucial environmental functions, including coastal protection, sediment stabilization, wave energy reduction, and water quality improvement, which help maintain ecological balance and support local communities.

At the same time, continuous investment in mangrove restoration and replanting has been made by the Department of Marine and Coastal Resources (DMCR), local governments, and community networks to enhance coastal resilience, carbon sequestration, and habitat recovery. The following table 12 summarizes the estimated economic values derived from environmental services and the financial investments dedicated to restoration efforts in each study area, highlighting their collective contribution to Thailand's blue economy and sustainable coastal management.

Table 12. Environmental Service Values and Restoration Investment in Coastal and Estuarine Ecosystems

Name of area	Values from environmental services	Value of investment
MG1: Welu River Estuary	The Welu River Estuary provides key environmental services that protect and sustain the coastal ecosystem. The mangrove forests help reduce wave energy, prevent erosion, and stabilize sediments, while also improving water quality by filtering pollutants and trapping sediments. The combined value of these ecosystem functions is estimated at around US$4–6 million per year, highlighting their importance in coastal protection and environmental resilience.	The Welu River Estuary has benefited from continuous mangrove restoration and replanting projects implemented by the DMCR and local communities to enhance coastal resilience. Covering about 200–300 hectares, with an average restoration cost of US$1,500–2,500 per hectare, the total investment value is estimated at US$0.3–0.6 million. These efforts strengthen coastal protection, carbon sequestration, and biodiversity recovery, supporting sustainable ecosystem management in the area.
MG2: Bandon Bay	The Bandon Bay ecosystem provides valuable environmental services that maintain coastal stability and ecological balance. Its extensive mangrove forests protect the shoreline by reducing wave energy, preventing erosion, and stabilizing sediments, while also enhancing water quality through nutrient absorption and pollutant filtration. The total value of these combined	The Bandon Bay area has received sustained investment in mangrove restoration and replanting led by the DMCR, provincial authorities, and local communities to enhance coastal protection and fisheries productivity. Restoration projects have covered approximately 300–400 hectares of degraded mangrove areas, with an average cost of US$1,500–2,500 per

	environmental services is estimated at around US$5–7 million per year, underscoring the bay's critical role in coastal protection, sediment retention, and ecosystem health in the Gulf of Thailand.	hectare, resulting in a total investment value of around US$0.45–1.0 million. These efforts have improved shoreline stability, carbon sequestration capacity, and nursery habitats, reinforcing the bay's role as a key model for sustainable coastal ecosystem recovery in southern Thailand.
MG3: Pak Panang Bay	The Pak Panang Bay ecosystem provides essential environmental services that help maintain the stability and productivity of the deltaic coast. Its mangrove forests act as natural barriers, reducing wave energy, preventing coastal erosion, and stabilizing sediments, while also improving water quality by trapping nutrients and filtering contaminants from river runoff. The total value of these combined services is estimated at around US$4–6 million per year, highlighting the bay's critical role in coastal protection, sediment retention, and ecological resilience for the lower Gulf of Thailand.	The Pak Panang Bay area has seen continuous investment in mangrove restoration and replanting by the DMCR, local government, and community networks to rehabilitate degraded coastal zones and support delta stability. Restoration projects cover about 400–500 hectares, with an average cost of US$1,500–2,500 per hectare, bringing the total investment value to approximately US$0.6–1.2 million. These initiatives have enhanced coastal protection, sediment retention, and blue carbon storage, while strengthening local livelihoods and climate resilience in the lower Gulf of Thailand.
MG: Samut Prakan Province	The Samut Prakan coastal zone provides important environmental services that support coastal protection and urban resilience. The remaining mangrove forests along the lower Chao Phraya estuary help reduce wave energy, prevent shoreline erosion, and	The Samut Prakan coastal zone has undergone targeted mangrove restoration and replanting efforts initiated by the DMCR, local authorities, and private sector partners to mitigate coastal erosion and improve environmental quality.

	stabilize sediments, while also improving water quality by filtering urban runoff and trapping pollutants. These functions are especially vital in a highly industrialized and urbanized setting. The total value of these combined environmental services is estimated at around US$3–4 million per year, underscoring the importance of conserving remaining mangrove areas to maintain coastal stability, water quality, and climate resilience.	Restoration activities have focused mainly on areas such as Bang Pu and Khlong Dan, covering about 100–150 hectares of degraded mangroves. With an average cost of US$1,500–2,500 per hectare, the total investment value is estimated at US$0.15–0.35 million. These initiatives have strengthened coastal protection, flood mitigation, and urban ecological resilience, serving as vital green buffers for Thailand's rapidly developing coastal zone.
WL1: Don Hoi Lot	The Don Hoi Lot Wetland provides vital environmental services that help maintain the ecological stability of the Mae Klong River estuary. The area's mangrove forests and extensive tidal flats serve as natural barriers, reducing wave energy, preventing erosion, and stabilizing sediments, while also improving water quality by filtering nutrients and trapping contaminants from river and coastal runoff. These combined ecosystem functions are valued at approximately US$4–5 million per year, highlighting the wetland's crucial role in coastal protection, sediment retention, and sustaining environmental health in Thailand's upper Gulf region.	The Don Hoi Lot Wetland has benefited from continuous mangrove restoration and replanting projects led by the DMCR and local communities to preserve coastal ecosystems and protect tidal flats. Restoration efforts have covered about 150–200 hectares, with an average cost of US$1,500–2,500 per hectare, giving a total investment value of around US$0.2–0.5 million. These initiatives enhance coastal protection, sediment stabilization, and biodiversity conservation, supporting the long-term sustainability of this Ramsar-designated wetland.

Potential Sustainable Use Values and Total Economic Values of Coastal and Estuarine Ecosystems

This review presents a summary of the potential sustainable use values and total economic values (TEV) of five coastal and estuarine areas—Welu River Estuary, Bandon Bay, Pak Panang Bay, Samut Prakan Province, and Don Hoi Lot. These areas show high potential for eco-friendly aquaculture, community-based ecotourism, and blue carbon initiatives, generating income while conserving ecosystems. The Total Economic Value reflects the combined benefits from all ecosystem services, emphasizing their importance in supporting local livelihoods, climate resilience, and Thailand's blue economy. The table 13 summarizes each area's sustainable use potential and overall economic value.

Table 13. Potential Sustainable Use Values and Total Economic Values of Coastal and Estuarine Ecosystems

Name of area	Values of potential (commercial) sustainable use	Total Economic Value
MG1: Welu River Estuary	The Welu River Estuary has strong potential for sustainable commercial use, particularly in eco-friendly aquaculture, community-based ecotourism, and blue carbon projects. These opportunities can generate income while conserving natural resources. The estimated potential value is around US$2–3 million per year, reflecting the estuary's capacity to support low-impact economic growth and climate-resilient livelihoods.	≈ US$35–45 million per year (approximately THB 1.25–1.6 billion per year)
MG2: Bandon Bay	The Bandon Bay area shows strong potential for sustainable commercial use that supports both economic growth and ecosystem conservation. Opportunities include eco-friendly aquaculture such as mangrove-integrated shrimp and oyster farming, which can enhance productivity while minimizing environmental impacts. The bay also has potential for	US$40–50 million per year (approximately THB 1.4–1.8 billion per year)

	ecotourism development, focusing on mangrove trails, oyster farming experiences, and community-based coastal tours. In addition, its extensive mangrove forests could generate income through blue carbon credit projects. The estimated potential value is around US$3–4 million per year, highlighting Bandon Bay's capacity to promote sustainable livelihoods and blue economy initiatives in southern Thailand.	
MG3: Pak Panang Bay	The Pak Panang Bay area has high potential for sustainable commercial use, particularly in mangrove-friendly aquaculture, ecotourism, and blue carbon initiatives. Integrated aquaculture systems and eco-based tourism focusing on the delta's mangrove and wetland landscapes can generate income while preserving environmental integrity. Additionally, the bay's extensive mangrove forests offer opportunities for participation in carbon credit projects. The estimated potential value is around US$2.5–3.5 million per year, highlighting its role in promoting sustainable livelihoods and nature-based economic development in the lower Gulf of Thailand.	≈ US$40–50 million per year (approximately THB 1.4–1.8 billion per year)
MG: Samut Prakan Province	The Samut Prakan coastal zone has potential for sustainable commercial use that integrates economic activities with	≈ US$20–25 million per year (approximately THB 720–900 million per year)

	environmental restoration. Opportunities include eco-industrial tourism, mangrove-based education and recreation programs in areas like Bang Pu, and community-led blue carbon initiatives that utilize remaining mangrove forests for carbon credit generation. Sustainable aquaculture and green business models can also enhance local income while reducing environmental impacts. The estimated potential value is around US$2–3 million per year, reflecting the province's capacity to promote low-carbon urban development and coastal ecosystem rehabilitation alongside economic growth.	
WL1: Don Hoi Lot	The Don Hoi Lot Wetland holds strong potential for sustainable commercial use that balances local economic development with environmental conservation. Key opportunities include community-based shellfish aquaculture and ecotourism, such as mudflat excursions, mangrove education trails, and cultural seafood tourism, which can generate steady income while preserving ecosystem integrity. In addition, the site's mangrove and tidal flat ecosystems offer potential for blue carbon credit projects that support climate action and community financing. The estimated potential value is around	≈ US$25–30 million per year (approximately THB 900 million–1.1 billion per year)

	US$2–3 million per year, underscoring Don Hoi Lot’s role as a model for nature-based sustainable livelihoods and coastal ecosystem conservation in the Upper Gulf of Thailand.	

Coral and seagrass areas

- **Geographic information**

Total area, areas of coral reef and reef type

An assessment of coral reef and seagrass distribution across sites in the Gulf of Thailand reveals distinct spatial variability in extent and ecosystem typology. The largest coral reef area is recorded at Koh Kood (13.18 km²), followed by Koh Mak (5.04 km²), Koh Lan (1.18 km²), and Koh Tao (0.66 km²), all characterized predominantly by *fringing reefs* and *patch reefs* typical of island-associated formations. Smaller but ecologically important reefs occur at Koh Si Chang (0.35 km²), Koh Losin (0.35 km²), and Koh Kra (0.13 km²), where isolated fringing and patch reef complexes provide refuge for marine biodiversity. The underwater pinnacles in Chumphon Province, though lacking quantitative coral area data, represent unique offshore habitats with high ecological value.In contrast, extensive seagrass meadows dominate Ban Don Bay (12.74 km²) and Chumphon (11.64 km²), serving as critical nursery and feeding grounds for coastal fisheries and megafauna. Collectively, these patterns highlight the geomorphological diversity of reef and seagrass ecosystems in the Gulf of Thailand, emphasizing the need for site-specific conservation and monitoring to sustain their ecological and economic functions. (Table 11)

Table 11. Coral and seagrass areas in Thailand (Gulf of Thailand): Geographic information showing total area, areas of coral reef and reef type

Name of area	Total area (km^2)	Areas of coral reef (km^2)		Type	
		Areas of coral reef (km^2)	Areas of seagrass (km^2)	Reef type	Seagrass type
CR:1 Koh Si Chang		0.35	-	Fringing Reef	-
CR:2 Koh Lan		1.18	-	Fringing Reef / Patch Reef	-
CR:3 Koh Kood		13.18	-	Fringing Reef	-
CR:4 Koh Mak		5.04	-	Fringing Reef	-
CR:5 Koh Tao		0.66	-	Fringing Reef / Patch Reef	-
CR:6 Koh Kra		0.13	-	Small fringing reefs, patch reefs	-
CR:7 Koh Losin		0.35	-	Fringing Reef/ Small patch reefs	-
CR:8 Underwater pinnacle			-	-	

Chumphon Province					
SG1: Ban Don Bay		-	12.74		
SG2: Chumphon		-	11.64		

- **Environmental state information**
  Present status, composition of coral reefs (live coral, dead coral, sand, rock and other)

An assessment of coral reef conditions across sites in the Gulf of Thailand demonstrates distinct variability in reef health and substrate composition. The highest proportion of live coral cover is recorded at Koh Losin (69.50%), followed by Koh Tao (61.27%) and Koh Kra (59.52%), representing healthy to remarkably healthy reef conditions characterized by high structural complexity and ecological integrity. Koh Lan (39.50%) and Koh Kood (33.45%) exhibit moderately healthy conditions with a balanced mix of live and dead corals, while Koh Si Chang (29.24%) and Koh Mak (29.69%) show degraded to moderately healthy states, marked by higher proportions of dead coral and sand, reflecting anthropogenic impacts such as sedimentation and tourism pressure. The underwater pinnacles in Chumphon Province maintain healthy reef status with 31.11% live coral and notable rock substrate (23.77%), suggesting resilience under moderate disturbance. In contrast, seagrass habitats are concentrated in Ban Don Bay (12.74%) and Chumphon (11.64%), highlighting their ecological importance as complementary ecosystems to coral reefs. Overall, these patterns illustrate a clear spatial gradient in reef condition, emphasizing the need for targeted monitoring and adaptive management to enhance reef recovery, sustain biodiversity, and maintain ecological balance across the Gulf of Thailand. (Table 12)

Table 12. Coral and seagrass areas in Thailand (Gulf of Thailand): Environmental state information showing present status, composition of coral reefs (live coral, dead coral, sand, rock and other)

Name of area	Present status	Composition (%)					
		Composition of coral reefs (%)					Composition of seagrass (%)
		Live coral	Dead coral	Sand	Rock	Other	
CR:1 Koh Si Chang	Degraded condition	29.24	12.48	9.58	39.34	9.32	-
CR:2 Koh Lan	Degraded condition	39.50	34.68	9.40	13.90	2.55	-
CR:3 Koh Kood	Moderately healthy	33.45	44.91	20.49	0.31	0.83	-
CR:4 Koh Mak	Moderately healthy	29.69	43.33	7.04	19.58	0.36	-
CR:5 Koh Tao	Healthy condition	61.27	35.64	0.40	1.71	0.98	-
CR:6 Koh Kra	Remarkably healthy	59.52	32.50	1.80	6.15	0.00	-
CR:7 Koh Losin	Healthy condition	69.50	29.00	1.30	0.00	0.30	-

Name of area	Present status	Composition (%)					
		Composition of coral reefs (%)					Composition of seagrass (%)
		Live coral	Dead coral	Sand	Rock	Other	
CR:8 Underwater pinnacle Chumphon Province	Healthy condition	31.11	27.21	16.76	23.77	1.15	-
SG1: Ban Don Bay	Moderately healthy	-	-	-	-	-	12.74
SG2: Chumphon		-	-	-	-	-	11.64

Threats, trends of change and future threats

Coral reef and seagrass ecosystems across the Gulf of Thailand — including Koh Si Chang, Koh Lan, Koh Kood, Koh Mak, Koh Tao, Koh Kra, Koh Losin, and the underwater pinnacles in Chumphon Province — face diverse and interlinked environmental pressures. Current threats are dominated by sedimentation, coastal development, pollution from urban and tourism sources, coral bleaching, and thermal stress, leading to reduced coral cover and degradation of seagrass meadows. Localized impacts from anchoring, boat traffic, and wastewater discharge further contribute to ecosystem decline, especially near major coastal hubs.

Trends of change indicate that coral cover has declined in nearshore sites such as Koh Si Chang and Koh Lan due to chronic sedimentation and pollution, while offshore reefs like Koh Kra and Koh Losin have remained stable or improved under low human pressure. Seagrass beds in sheltered bays such as Ban Don Bay and Chumphon show fluctuating but generally declining trends due to land-based runoff and aquaculture expansion.

Future threats include continued coastal development, increasing tourism pressure, climate-induced coral bleaching, and ocean acidification, which could accelerate biodiversity loss if unmanaged. Expanding ports, shipping lanes, and aquaculture zones also present new risks to water quality and habitat integrity.

Overall, these findings emphasize the urgent need for integrated coastal zone management, adaptive conservation planning, and sustainable tourism strategies to mitigate future threats and enhance the resilience of coral reef and seagrass ecosystems throughout the Gulf of Thailand. (Table 13)

Table 13. Coral and seagrass areas in Thailand (Gulf of Thailand):
Environmental state information showing present threats, trends of change and future threats

Name of area	Present threats	Trends of change	Future threats
CR:1 Koh Si Chang	**Sedimentation:** High and chronic from port, dredging, and ship anchoring around Si Racha–Laem Chabang, causing reduced coral growth	Live coral cover at Koh Si Chang has shown a gradual decrease over time due to chronic sedimentation, pollution, and	**Live Coral Cover and Density:** Future projections indicate a continued decline in live coral cover and density if current pressures

Name of area	Present threats	Trends of change	Future threats
	and water clarity. **Destructive Fishing:** No reported bombing or cyanide cases in recent years; low current threat level. **Pollution:** Influenced by Si Racha (~323,800 people) and Laem Chabang Port (~10 km away). Microplastic levels range **0.02–42.46 particles/m³** — indicating persistent contamination. **Crown-of-Thorns (COT):** No current outbreak; densities below the outbreak threshold (>14 ind./1,000 m²). **Bleaching:** • 2010 – Severe bleaching, high mortality. • 2014–2015 – Mild. • 2016 – Moderate impact in the Gulf (~36% of stations affected). • 2019 – Thermal stress but low mortality. • 2024 – Low bleaching (13–18%) nearby; reefs maintain **12–28% live cover**, dominated by *Porites lutea*.	repeated bleaching events. Historical surveys reported coral cover of around 30–40% in the early 2000s, which has declined to approximately 12–28% in recent years. Coral density and species diversity have also decreased, with a shift toward dominance of massive, stress-tolerant species such as *Porites lutea* and *Dipsastraea favus*.	persist. Chronic sedimentation, thermal stress, and pollution from surrounding industrial and port areas are expected to limit coral recruitment and recovery. Without effective management, coral cover currently around 12–28% may continue to decrease, and reef structure could shift further toward dominance by stress-tolerant species (*Porites lutea*, *Favia* spp.) with reduced biodiversity. **Development Plan and Distance to the Coral Reef:** Koh Si Chang lies within 10–12 km of major industrial and port development zones, including Laem Chabang Port and Si Racha coastal industries. Future expansion of shipping lanes, port infrastructure, and coastal construction poses significant risks through increased sedimentation, turbidity, wastewater discharge, and oil spills. Tourism-related infrastructure on the

Name of area	Present threats	Trends of change	Future threats
			island also contributes to localized impacts such as anchor damage and untreated wastewater.
CR:2 Koh Lan	**Sedimentation:** High sedimentation stress from tourism, dredging, and runoff reduces coral growth and water clarity. **Destructive Fishing:** No reported bombing or cyanide fishing cases; estimated **0 cases per year**. **Pollution:** Main sources from **Pattaya City (~120,000 people, ~7 km away)**. Wastewater discharge, boat activities, and plastic waste cause chronic pollution. Microplastics range **0.02–45 particles/m³**. **Crown-of-Thorns (COT):** No outbreak recorded in the past decade. Density remains **below 14 individuals/1,000 m²** (non-outbreak level). **Bleaching:** • **2010:** Severe bleaching (>50% mortality in shallow reefs). • **2014–2015:** Mild bleaching, quick recovery.	Live coral cover and density at Koh Lan have decreased over the past two decades due to heavy tourism pressure, sedimentation, and coastal pollution from nearby Pattaya. Historical data indicate coral cover of around 30–40% in the early 2000s, declining to 10–25% in recent years. The reduction is most pronounced in shallow reef zones affected by turbidity, anchor damage, and wastewater discharge. Coral density has also declined, with a shift toward dominance of massive, stress-tolerant species such as *Porites lutea* and *Dipsastraea* spp., replacing formerly abundant branching Acropora corals.	**Live Coral Cover and Density:** Live coral cover and density at Koh Lan are projected to continue decreasing without improved management. Chronic stress from tourism, sedimentation, and wastewater pollution will likely cause further coral decline, especially in shallow reef zones already dominated by stress-tolerant species (Porites lutea, Favia spp.). Without intervention, coral cover currently around 10–25% could drop below 10% in heavily visited areas within the next decade. **Development Plan and Distance to the Coral Reef:** Koh Lan is located about 7 km from Pattaya City, a major tourism and urban hub with ongoing expansion of resorts, piers, and marine transport facilities. Planned

Name of area	Present threats	Trends of change	Future threats
	• **2016:** Moderate to severe (~30–40% bleached). • **2019:** Localized bleaching, low mortality. • **2024:** Low bleaching (10–20%), ongoing recovery.	Although minor recovery has occurred after mild bleaching events in recent years, the overall trend remains decreasing, with reef structure and biodiversity gradually degrading. Continued pollution control and responsible tourism practices are essential to reverse the decline.	developments, including coastal infrastructure upgrades and increased tourist capacity, pose risks from sediment runoff, nutrient loading, and anchor damage. Many coral reefs lie within 200–500 meters of beaches and piers, making them highly vulnerable to land-based and in-water disturbances.
CR:3 Koh Kood	**Sedimentation:** Low to moderate sedimentation. Reefs benefit from good water circulation, though localized sedimentation occurs near resorts and piers due to construction and runoff. **Destructive Fishing:** No reported cases of bombing or cyanide fishing in recent years. Estimated **0 cases per year**. Local fisheries are mostly small-scale and regulated. **Pollution:** Main sources from **Trat Province (population ~230,000)**, with Koh Kood located **~40 km offshore**. Pollution mainly from domestic wastewater and	Live coral cover and density at Koh Kood have shown a stable to slightly increasing trend over the past decade. Coral cover, which declined moderately after the 2010 and 2016 bleaching events, has since recovered well, supported by clear water, low sedimentation, and limited coastal development. Recent surveys indicate coral cover of 30–50%, dominated by *Acropora*, *Porites*, and *Dipsastraea* species, reflecting both high diversity and good reef	**Live Coral Cover and Density:** Live coral cover and density at Koh Kood are currently healthy but may face moderate decline in the future if tourism and coastal development expand without effective management. Coral cover—now around 30–50%—could decrease due to increased sedimentation, wastewater discharge, and anchor damage if visitor pressure continues to rise. Although reefs are dominated by resilient species (*Acropora*, *Porites*, *Favia*), they remain

Name of area	Present threats	Trends of change	Future threats
	tourism activities. Overall water quality remains good; low nutrient and debris levels compared to mainland bays. **Crown-of-Thorns (COT):** Occasional sightings but **no major outbreak** reported. Densities remain **below 14 individuals/1,000 m²**. Regular monitoring by DMCR and local dive operators. **Bleaching:** • **2010:** Moderate bleaching; partial recovery within a year. • **2014–2015:** Mild bleaching. • **2016:** Moderate bleaching (~20–30% of live coral affected). • **2019:** Minor bleaching, no significant mortality. • **2024:** Low bleaching (<10%) and good recovery observed.	health. Coral density has also improved in several sites, particularly in sheltered bays and offshore reef zones. Overall, the trend at Koh Kood shows recovery and gradual increase in live coral cover and density, driven by favorable environmental conditions and relatively low human impact compared to more developed tourist islands.	vulnerable to climate-induced bleaching and local stressors. **Development Plan and Distance to the Coral Reef:** Koh Kood is under ongoing development as a high-end eco-tourism destination, with new resorts and infrastructure planned along the coastline. Most coral reefs are within 100–300 meters from the shore, making them sensitive to runoff, coastal construction, and wastewater discharge. Expansion of roads, piers, and beachfront resorts increases the risk of sedimentation and nutrient input to nearshore reefs.
CR:4 Koh Mak	**Sedimentation:** Low sedimentation overall due to clear offshore waters and limited coastal development. Minor localized sediment	Live coral cover and density at Koh Mak have shown a slightly increasing trend over the past decade. After moderate declines	**Live Coral Cover and Density:** Live coral cover and density at Koh Mak are currently stable to slightly increasing, but may

Name of area	Present threats	Trends of change	Future threats
	accumulation near resorts and piers during heavy rainfall or construction. **Destructive Fishing:** No bombing or cyanide fishing reported in recent years; estimated **0 cases per year**. Local fisheries are small-scale and community-managed. **Pollution:** Main pollution sources from **Trat Province (~230,000 population)** and nearby **Laem Ngop District (~35 km away)**. Pollution mainly from domestic wastewater and tourism activities, but overall water quality remains good with low nutrient levels and minimal debris. **Crown-of-Thorns (COT):** No outbreak recorded. Occasional individuals found but **densities below outbreak threshold (>14 individuals/1,000 m²)**. Regular monitoring by DMCR and local dive centers. **Bleaching:** • **2010:** Moderate bleaching, partial recovery within 1–2 years.	during the 2010 and 2016 bleaching events, most reef sites have recovered steadily, supported by clear waters, low sedimentation, and limited urban development. Current coral cover is estimated at 30–55%, with high diversity dominated by Acropora, Porites, and Favia species. Coral recruitment and density have improved in shallow and mid-depth reefs, indicating good natural regeneration. Overall, Koh Mak reefs exhibit a positive recovery trend with stable or increasing coral cover and density, reflecting effective natural resilience and low anthropogenic stress compared to other islands in the Gulf of Thailand.	decline in the future if tourism expansion and coastal development intensify. Coral reefs with current cover of 30–55% could face stress from sedimentation, wastewater discharge, and anchor damage if not managed sustainably. While resilient species (*Acropora*, *Porites*, *Favia*) dominate, rising sea surface temperatures and potential bleaching events also pose ongoing threats. **Development Plan and Distance to the Coral Reef:** Koh Mak is being promoted as a low-carbon and sustainable tourism island, yet small-scale resort development, pier construction, and increased boat traffic are expanding. Most coral reefs lie within 100–500 meters of the coastline, especially along Ao Kao, Ao Nid, and Ao Suan Yai, making them highly sensitive to land-based runoff and human disturbance.

Name of area	Present threats	Trends of change	Future threats
	• **2014–2015:** Mild bleaching. • **2016:** Moderate bleaching (~20–30% affected), limited mortality. • **2019:** Minor bleaching, good recovery. • **2024:** Low bleaching (<10%), healthy recovery trend.		
CR:5 Koh Tao	**Sedimentation:** Generally low to moderate. Water clarity remains good at most dive sites, though localized sedimentation occurs near coastal development, piers, and runoff areas, especially during monsoon periods. Sediment stress can reduce coral recruitment in nearshore reefs. **Destructive Fishing (bombing & poisoning):** No recent reports of bombing or cyanide fishing. The area is heavily managed as a marine tourism zone with **0 reported cases per year**. Local fishing is small-scale and regulated by community and DMCR patrols. **Pollution**	Live coral cover and density at Koh Tao have shown a fluctuating but generally recovering trend over the past 15 years. Severe bleaching events in 2010 and 2016 caused widespread coral mortality, reducing live coral cover to below 20% in many shallow reef areas. Since then, active reef restoration programs, improved coastal management, and natural recruitment have supported gradual recovery, with current coral cover reaching 25–45% at several sites. Coral density has also increased,	**Live Coral Cover and Density:** Live coral cover and density at Koh Tao are currently recovering after past bleaching events, but they remain highly vulnerable to future declines. Increasing sea surface temperatures, more frequent bleaching events, and local stressors such as sedimentation and nutrient runoff could reduce coral cover—now 25–45%—in coming years. Without continued restoration and management, coral density and diversity may decline, particularly in shallow, high-use dive sites.

Name of area	Present threats	Trends of change	Future threats
	(population & distance to sources): Koh Tao has a resident population of **~2,000–3,000** people, increasing to over **10,000** during peak tourism. Main pollution sources are **tourism wastewater, plastic waste, and boat discharges**. The island is about **70 km from Chumphon mainland**, so mainland pollution impact is minimal; however, localized nutrient buildup occurs near bays. **Crown-of-Thorns (COT):** Outbreaks occurred periodically, with localized infestations in **2010, 2014, and 2018**, controlled through manual removal. Current density is **below 14 individuals/1,000 m²**, indicating no active outbreak. **Bleaching:** • **2010:** Severe nationwide event; >50% of corals bleached, with significant mortality at shallow sites. • **2014–2015:** Moderate bleaching (~30%), partial	particularly in deeper reefs and protected bays. The overall trend indicates moderate recovery and slow increase in live coral cover and density, though reefs remain vulnerable to thermal stress, sedimentation, and high tourism pressure. Continued restoration and water quality management are crucial to sustaining this positive trajectory.	**Development Plan and Distance to the Coral Reef:** Koh Tao is a major dive tourism destination with continuous infrastructure expansion, including resorts, piers, and waste treatment facilities. Many coral reefs are located within 50–300 meters of the shoreline, directly exposed to runoff, wastewater discharge, and anchor damage. Planned tourism growth and increasing visitor numbers may intensify these pressures if environmental capacity limits are exceeded.

Name of area	Present threats	Trends of change	Future threats
	recovery observed. • **2016:** Severe bleaching (>50%), widespread mortality at exposed sites. • **2019:** Mild bleaching (<20%), limited impact. • **2024:** Low bleaching (<10%) and continued recovery, dominated by resilient *Porites* and *Pocillopora* species.		
CR:6 Koh Kra	**Sedimentation:** Low sedimentation overall due to offshore location and clear oceanic waters. Minimal coastal development and limited runoff help maintain high water clarity and healthy coral growth. **Destructive Fishing (bombing & poisoning):** No bombing or cyanide fishing reported in recent years; estimated **0 cases per year**. The area is under **strict protection** and regular patrols by DMCR and the Royal Thai Navy. **Pollution (population &	Live coral cover and density at Koh Kra have shown a stable to slightly increasing trend over the past two decades. The reefs, located far offshore and free from direct land-based impacts, have largely maintained high coral cover (40–70%) with minimal degradation. After the 2010 and 2016 bleaching events, some shallow corals experienced temporary decline, but rapid natural recovery was observed within 1–2 years. Coral	**Live Coral Cover and Density:** Coral cover and density at Koh Kra are currently high and stable, but future threats could cause localized declines if not effectively managed. Potential stressors include climate-induced bleaching, rising sea temperatures, and ocean acidification. Although coral cover is now 40–70%, increased thermal stress events could lead to temporary losses in sensitive *Acropora* species, even though massive corals (*Porites*, *Montipora*)

Name of area	Present threats	Trends of change	Future threats
	distance to sources): Koh Kra is **~70 km offshore from Nakhon Si Thammarat Province**, with **no resident population**. Pollution impact is very low, limited mainly to transient fishing and boat traffic. Water quality is generally excellent, with negligible nutrient and plastic contamination. **Crown-of-Thorns (COT):** No outbreak recorded in the past decade. Occasional sightings of individual starfish, but densities remain **well below 14 individuals/1,000 m²**. **Bleaching:** • **2010:** Severe bleaching event nationwide; significant bleaching (>50%) in shallow zones, with moderate mortality. • **2014–2015:** Mild bleaching, full recovery within a year. • **2016:** Moderate bleaching (~30%), partial mortality observed.	density remains high, dominated by diverse assemblages of *Acropora*, *Porites*, and *Montipora* species. Overall, Koh Kra reefs exhibit a positive and stable trend, with healthy coral cover, strong recruitment, and minimal anthropogenic disturbance, making it one of the most pristine reef systems in the Gulf of Thailand.	are likely to persist. **Development Plan and Distance to the Coral Reef:** Koh Kra is an uninhabited offshore island, located ~70 km from Nakhon Si Thammarat Province, with no direct coastal development nearby. However, indirect threats may arise from offshore shipping routes, oil transport, and fishing activities in adjacent waters. Potential expansion of maritime routes or offshore energy infrastructure could increase risks of sedimentation, pollution, and accidental spills affecting nearby coral reefs.

Name of area	Present threats	Trends of change	Future threats
	• **2019:** Low bleaching (<15%), good resilience noted. • **2024:** Minimal bleaching (<10%), high recovery and coral health maintained.		
CR:7 Koh Losin	**Sedimentation:** Very low sedimentation due to its remote offshore location and absence of terrestrial runoff. The surrounding waters are clear year-round, providing excellent conditions for coral growth and high reef complexity. **Destructive Fishing (bombing & poisoning):** No reported bombing or cyanide fishing in recent years; estimated **0 cases per year**. The site is **strictly protected** by the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy as part of national conservation patrols. **Pollution (population & distance to sources):** Koh Losin is approximately 72 km offshore from Pattani Province, with no	Live coral cover and density at Koh Losin have remained high and stable over the past two decades. Due to its remote offshore location and lack of human settlement, the reefs are minimally disturbed and maintain exceptional water clarity and habitat quality. Although bleaching events in 2010 and 2016 caused temporary coral paling and partial mortality in shallow zones, recovery was rapid, and overall live coral cover has remained at 50–80%. Coral density and species richness continue to be among the highest in the Gulf of Thailand, dominated by *Acropora*, *Pocillopora*,	**Live Coral Cover and Density:** Coral cover and density at Koh Losin are currently high and stable (50–80%), but future threats from climate change and ocean warming could lead to periodic decreases. Intensifying bleaching events, coral disease outbreaks, and ocean acidification may cause partial mortality, especially in shallow reef zones dominated by *Acropora* and *Pocillopora*. While recovery potential is high, repeated thermal stress could reduce coral diversity and structural complexity over time. **Development Plan and Distance to the Coral Reef:** Koh Losin is a remote offshore pinnacle, located

Name of area	Present threats	Trends of change	Future threats
	resident population or nearby settlements. Pollution levels are extremely low, with minimal influence from coastal or human sources. Occasional marine debris from distant fishing activities may occur but remains limited. **Crown-of-Thorns (COT):** No outbreak records. Occasional individuals observed during surveys, but densities remain far below outbreak threshold (>14 individuals/1,000 m²). **Bleaching:** • **2010:** Severe bleaching event; ~50–60% of corals affected, moderate mortality in shallow zones. • **2014–2015:** Mild bleaching; most corals recovered within one year. • **2016:** Moderate bleaching (~25–35%), minor mortality. • **2019:** Low bleaching (<15%), minimal impact.	*Montipora*, and *Porites*. Overall, Koh Losin shows a stable or slightly increasing trend in live coral cover and density, supported by strong natural resilience, limited anthropogenic pressure, and effective protection by national authorities.	about 72 km from Pattani Province, with no onshore development or settlement nearby. Although direct land-based impacts are absent, indirect threats may emerge from increased shipping traffic, offshore energy exploration, and marine debris transported by ocean currents. Any future maritime development or oil transport expansion in the Gulf of Thailand could pose significant risks through sediment disturbance or pollution events.

Name of area	Present threats	Trends of change	Future threats
	• **2024:** Very low bleaching (<5%), indicating strong coral thermal tolerance and recovery.		
CR:8 Underwater pinnacle Chumphon Province	**Sedimentation:** Low to moderate sedimentation. The pinnacles are located offshore and benefit from good water circulation, though nearshore sites can experience increased turbidity and sedimentation during monsoon seasons and from riverine runoff. Overall sedimentation stress remains limited compared to coastal reefs. **Destructive Fishing (bombing & poisoning):** No reported bombing or cyanide fishing in recent years; estimated **0 cases per year**. The area is managed under the **Chumphon Archipelago Marine Protected Area**, with regular patrols by DMCR and local authorities. **Pollution (population & distance to sources):** Chumphon City has a population of	Live coral cover and density at Koh Losin have remained high and stable over the past two decades. Due to its remote offshore location and lack of human settlement, the reefs are minimally disturbed and maintain exceptional water clarity and habitat quality. Although bleaching events in 2010 and 2016 caused temporary coral paling and partial mortality in shallow zones, recovery was rapid, and overall live coral cover has remained at 50–80%. Coral density and species richness continue to be among the highest in the Gulf of Thailand, dominated by *Acropora*, *Pocillopora*, *Montipora*, and *Porites*. Overall, Koh Losin	**Live Coral Cover and Density:** Live coral cover and density at Chumphon's underwater pinnacles are currently moderate to good (12–28%), with stable conditions in deeper sites. However, future projections indicate a potential decrease if environmental pressures increase. Key threats include climate-induced bleaching, sedimentation from coastal runoff, and nutrient enrichment from expanding coastal aquaculture. Without effective management, coral recovery rates may slow, and overall diversity could decline. **Development Plan and Distance to the Coral Reef:** The underwater pinnacles are located 15–25 km offshore from Chumphon City,

Name of area	Present threats	Trends of change	Future threats
	~200,000, located approximately **20–25 km from the main pinnacle sites**. Pollution sources include river discharge, coastal runoff, and limited boat traffic. Offshore sites have **low nutrient and plastic pollution**, though localized contamination can occur near ports or fishing zones. **Crown-of-Thorns (COT):** No major outbreak reported in the last decade. Occasional sightings recorded during surveys, but densities remain **below outbreak threshold (>14 individuals/1,000 m²)**. **Bleaching:** • **2010:** Severe bleaching (>50% of corals affected), with partial mortality. • **2014–2015:** Mild bleaching, quick recovery observed. • **2016:** Moderate bleaching (~30–40%), moderate mortality in shallow zones.	shows a stable or slightly increasing trend in live coral cover and density, supported by strong natural resilience, limited anthropogenic pressure, and effective protection by national authorities.	where ongoing coastal tourism and port development are expanding. Planned infrastructure improvements—such as pier extensions, increased boat traffic, and nearby aquaculture growth—could increase sedimentation and pollution reaching offshore sites via currents. Although the reefs are relatively distant from direct coastal development, cumulative impacts from inland runoff and maritime activities pose emerging risks.

Name of area	Present threats	Trends of change	Future threats
	• **2019:** Minor bleaching (<20%), full recovery within a year. • **2024:** Low bleaching (10–15% of live coral), strong recovery and high coral health observed.		
SG1: Ban Don Bay	**Sedimentation:** High sedimentation from river discharge (mainly Tapi and Phum Duang Rivers), aquaculture runoff, and tidal currents. Although water is highly turbid, many seagrass species tolerate low light and fine sediments, maintaining extensive coverage across the bay. Sediment deposition affects growth rates and species composition, favoring resilient taxa such as *Enhalus acoroides* and *Halophila ovalis*. **Pollution (population & distance to sources):** Main pollution sources originate from Surat Thani City (~130,000 people) and coastal settlements located 5–15 km from major seagrass meadows.	Seagrass cover and density in Ban Don Bay have shown a gradual decline over the past two decades, mainly due to sedimentation, nutrient enrichment, and coastal development. High sediment loads from river discharge and aquaculture runoff have reduced light penetration, affecting seagrass productivity and distribution. In the early 2000s, the bay supported over 20,000 hectares of continuous seagrass meadows. Recent assessments indicate a reduction to approximately 15,000 hectares, with lower shoot	**Live Seagrass Cover and Density:** Seagrass cover and density in Ban Don Bay are expected to continue decreasing in the future due to increasing sedimentation, nutrient enrichment, and physical disturbance. Current meadows—covering about 15,000 hectares—may experience further decline if sediment loads from rivers and aquaculture continue to rise. Excessive nutrient input could also promote algal blooms, reducing light availability and seagrass productivity. **Development Plan and Distance to the Seagrass:** Ban Don Bay is located 5–15 km from Surat Thani City, a growing

Name of area	Present threats	Trends of change	Future threats
	Wastewater and nutrient runoff from shrimp farms and domestic sources contribute to moderate-to-high nutrient enrichment, promoting algal overgrowth and sediment accumulation in shallow zones.	density and patchier distribution in nearshore areas. Despite these pressures, dominant species such as *Enhalus acoroides*, *Thalassia hemprichii*, and *Halodule uninervis* persist, showing resilience in deeper and less disturbed zones. Overall, the trend indicates a slow decrease in seagrass cover and density, driven by sedimentation, nutrient loading, and physical disturbance, though the ecosystem remains a vital habitat for dugongs and coastal fisheries.	urban and aquaculture hub. Future expansion of shrimp farms, coastal industry, and port facilities, along with urban wastewater discharge, will likely increase sedimentation and nutrient inflow into the bay. Planned infrastructure improvements along the bay's shoreline may further disrupt seagrass habitats through dredging and coastal modification.
SG2: Chumphon	**Sedimentation:** Moderate sedimentation influenced by coastal runoff, river discharge, and monsoon-driven currents. Sediment accumulation occurs mainly in nearshore and estuarine areas, such as Tha Sae and Lang Suan Districts, but most seagrass meadows remain healthy due to good	Seagrass cover and density in Chumphon have shown a stable to slightly decreasing trend over the past two decades. While extensive seagrass meadows still exist along sheltered bays and estuaries—particularly in Tha Sae, Lang Suan, and Pathio	**Live Seagrass Cover and Density:** Seagrass cover and density in Chumphon are projected to slightly decrease in the future due to increasing coastal activities, sedimentation, and nutrient loading. Expansion of aquaculture farms, agriculture, and tourism-related

Name of area	Present threats	Trends of change	Future threats
	water circulation and natural sediment tolerance. **Pollution (population & distance to sources):** Main pollution sources are from Chumphon City and coastal communities (~200,000 people) located 5–20 km from major seagrass areas. Domestic wastewater, aquaculture runoff, and small-scale tourism contribute to moderate nutrient enrichment and sedimentation. Offshore sites show relatively low pollution levels with good water quality.	Districts—localized declines have occurred near river mouths and coastal development areas. Earlier surveys recorded about 8,000–10,000 hectares of seagrass, but recent monitoring indicates slight reductions in both coverage and shoot density, mainly due to sedimentation, trawling disturbance, and nutrient runoff from aquaculture and agriculture. Dominant species such as *Enhalus acoroides*, *Halophila ovalis*, and *Halodule uninervis* remain abundant, showing good regeneration in less disturbed zones. Overall, the trend reflects minor decreases in seagrass cover and density, but the ecosystem remains in fairly good condition and continues to provide essential nursery and feeding habitats for marine fauna.	facilities along the coast may increase suspended sediments and organic matter, reducing light availability and seagrass productivity. Without effective management, current meadows—covering about 8,000–10,000 hectares could decline in both extent and shoot density, particularly in nearshore and estuarine zones. **Development Plan and Distance to the Seagrass:** Major seagrass beds occur within 0.5–2 km from the shoreline, especially around Tha Sae, Pathio, and Lang Suan Districts. Future coastal development plans, including harbor upgrades, aquaculture expansion, and coastal road construction, could increase runoff and alter sediment dynamics. These developments pose a high risk to shallow seagrass habitats due to their proximity to shore and low tolerance to turbidity.

Name of area	Present threats	Trends of change	Future threats

- **Social and use information**

  Ownership and management

A review of ownership and management arrangements for coral reef and seagrass areas across the Gulf of Thailand reveals a consistent state-led governance framework that underscores Thailand's commitment to sustainable marine resource stewardship. All surveyed sites are under state ownership, reflecting national policy priorities for public custodianship of ecologically significant marine habitats.

Management regimes are guided by integrated coastal and marine resource planning, combining land-use zoning, institutional collaboration, and stakeholder engagement. The Department of Marine and Coastal Resources (DMCR) plays a central coordinating role alongside provincial authorities, local governments, and, in offshore areas, the Royal Thai Navy. Across provinces such as Chonburi, Trat, Surat Thani, and Chumphon, management systems integrate conservation, fisheries, and tourism objectives within broader coastal development frameworks.

Restoration and conservation measures—including coral transplantation, seagrass rehabilitation, artificial reef installation, and marine debris management—are widely implemented through partnerships between DMCR, NGOs, universities, and local communities. Stakeholder participation is especially evident in community-based initiatives in Koh Kood, Koh Mak, and Koh Tao, where tourism operators and residents collaborate on reef monitoring, eco-tourism promotion, and waste reduction.

This standardized governance model, spanning from Koh Si Chang and Koh Lan to Ban Don Bay and Chumphon, illustrates a unified approach that balances ecological protection with livelihood sustainability. However, the long-term success of these arrangements depends on stronger enforcement, consistent funding, and adaptive management to address site-specific challenges, particularly those linked to coastal development, tourism pressure, and climate change impacts. (Table 14)

Table 14. Coral and seagrass areas in Thailand (Gulf of Thailand): Social and use information showing ownership and management regime

Name of area	Ownership	Management regime
CR:1 Koh Si Chang	State	Koh Si Chang is managed under Chonburi Province's coastal zoning plan, but enforcement is limited due to overlapping industrial, tourism, and conservation uses. The Department of Marine and Coastal Resources (DMCR) leads reef monitoring, while local authorities oversee land and tourism management. Coordination among DMCR, the Marine Department, and Laem Chabang Port Authority remains essential to address pollution and sedimentation. Stakeholder cooperation involves local

Name of area	Ownership	Management regime
		government, tourism operators, fishers, and port authorities, though co-management is still developing. Small-scale coral restoration and marine litter reduction projects are ongoing, supported by universities and dive groups. Fishing is mostly small-scale and non-destructive, but nearshore activity still affects coral habitats. Future priorities include stronger zoning enforcement, integrated land–sea planning, sustainable tourism, and a local conservation fund to enhance reef resilience and long-term management effectiveness.
CR:2 Koh Lan	State	Koh Lan is managed under Pattaya City and Chonburi Province's coastal zoning plan, focusing on tourism, fisheries, and environmental protection. However, rapid tourism growth and limited zoning enforcement have led to conflicts between development and reef conservation. The Department of Marine and Coastal Resources (DMCR) and Pattaya City Municipality are the main authorities overseeing marine resource management, wastewater treatment, and tourism regulation. Coordination among agencies remains weak, particularly in managing waste, anchoring, and nearshore reef protection. Stakeholders include local government, tourism operators, dive centers, and fishing communities. Some coral restoration and beach clean-up projects have been initiated by DMCR, local NGOs, and private tourism businesses, but sustained funding and long-term monitoring are limited. Fishing around Koh Lan is small-scale, mainly traps and lines, with no destructive fishing reported, though anchoring and coastal activities continue to disturb coral zones.
CR:3 Koh Kood	State	Koh Kood is managed under Trat Province's coastal and marine resource plan, emphasizing sustainable tourism, fisheries, and conservation. The Department of Marine and Coastal Resources (DMCR), Trat Provincial Office, and Koh Kood

Name of area	Ownership	Management regime
		Subdistrict Administrative Organization share responsibilities for reef protection, land-use control, and tourism management. Land-use planning promotes eco-tourism and low-impact development, with zoning that separates resort, fishing, and conservation areas. However, as tourism expands, stronger enforcement is needed to prevent wastewater discharge, coastal construction impacts, and anchor damage to nearby coral reefs. Stakeholder collaboration includes local authorities, tourism operators, resort owners, fishers, and community groups, working together on coral restoration, waste reduction, and sustainable tourism practices. Restoration activities, supported by DMCR and local NGOs, include small-scale coral transplantation and mooring buoy installation. Fishing around Koh Kood is small-scale and traditional, with no reports of destructive practices. Ongoing promotion of sustainable fishing zones and community awareness supports conservation goals.
CR:4 Koh Mak	State	Koh Mak is managed under Trat Province's coastal resource and tourism development plan, focusing on sustainable, low-impact tourism and marine ecosystem conservation. The Department of Marine and Coastal Resources (DMCR), Trat Provincial Office, and Koh Mak Subdistrict Administrative Organization coordinate management, while the Koh Mak Community Tourism Association plays a key role in local environmental stewardship. Land-use planning emphasizes eco-tourism zoning, with most coral reef areas located within designated conservation zones. Coastal development is regulated to limit construction near sensitive habitats, although enforcement capacity remains limited. Stakeholder coordination is relatively strong, involving local resorts, dive operators, DMCR, and community groups, which collaborate on coral reef monitoring, marine litter management, and environmental

Name of area	Ownership	Management regime
		awareness campaigns. Several coral restoration and mooring buoy projects have been initiated through community and private-sector partnerships. Fishing activity is small-scale and community-based, using traditional, non-destructive gear. Community regulations help restrict fishing in coral and seagrass areas, supporting reef recovery.
CR:5 Koh Tao	State	Koh Tao is managed under Surat Thani Province’s coastal and marine resource plan, with a focus on coral reef conservation, sustainable tourism, and community-based management. The Department of Marine and Coastal Resources (DMCR), Koh Tao Subdistrict Administrative Organization, and local tourism networks share responsibilities for environmental protection, waste management, and reef monitoring. Land-use planning promotes controlled tourism development, but continued infrastructure expansion and waste generation challenge enforcement. Most coral reefs lie within 50–300 meters of the shore, making them highly vulnerable to runoff, anchoring, and wastewater discharge from resorts and dive operations. Stakeholder collaboration is strong, involving local dive operators, NGOs, universities, and community groups. Initiatives such as coral nurseries, mooring buoy installation, reef clean-ups, and citizen science monitoring are well established. Koh Tao is a national model for community-driven coral restoration and marine conservation. Fishing is minimal and small-scale, with strict local regulations and marine protected zones that prohibit destructive practices.
CR:6 Koh Kra	State	Koh Kra is managed under the jurisdiction of the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy, as part of Thailand’s national marine conservation network. The island group is uninhabited and designated as a strict conservation area, focusing on coral reef protection, biodiversity conservation, and enforcement of fishery regulations. Land-use planning is minimal due to the

Name of area	Ownership	Management regime
		island's remote offshore location (~70 km from Nakhon Si Thammarat). No development or tourism infrastructure is permitted, and access is strictly controlled for research, conservation, and authorized patrol missions. Institutional coordination between the DMCR, Royal Thai Navy, and the Department of Fisheries ensures effective protection against illegal fishing and marine pollution. Regular monitoring and patrols are conducted to prevent destructive fishing and to protect coral reef habitats. Restoration and stakeholder involvement are limited but supported by scientific research programs and DMCR-led coral surveys. Occasional collaborative efforts with universities and conservation organizations contribute to long-term reef monitoring and biodiversity assessments. Fishery practices are highly restricted; commercial and destructive fishing are prohibited within the conservation boundaries. Only limited traditional or research-related fishing activities are occasionally permitted under strict supervision.
CR:7 Koh Losin	State	Koh Losin is managed under the Department of Marine and Coastal Resources (DMCR) in coordination with the Royal Thai Navy, serving as one of Thailand's most strictly protected offshore coral reef sites. Its remote location (~72 km from Pattani Province) and uninhabited status have kept human disturbance extremely low, allowing for high coral cover and biodiversity. Land-use planning is not applicable, as no permanent settlement or coastal infrastructure exists. The area is designated as a strict marine conservation zone, where development, tourism, and extractive activities are prohibited. Institutional framework involves the DMCR overseeing reef monitoring and conservation research, while the Royal Thai Navy enforces maritime protection against illegal fishing, anchoring, or oil transport threats.

Name of area	Ownership	Management regime
		Collaboration between government agencies supports ongoing reef health assessments and marine biodiversity monitoring. Stakeholder coordination is primarily inter-agency, focusing on national-level conservation policy rather than local community involvement due to the site's isolation. Occasional partnerships with research institutes and universities support ecological studies and coral assessments. Restoration activities are minimal, as the reefs remain largely intact. Management efforts emphasize protection and monitoring rather than active restoration. Fishery practices are strictly prohibited within the conservation boundaries, with regular naval patrols ensuring compliance and preventing illegal trawling or destructive fishing.
CR:8 Underwater pinnacle Chumphon Province	State	The underwater pinnacles of Chumphon Province are managed under the Chumphon Marine National Park and the Department of Marine and Coastal Resources (DMCR), with support from the Chumphon Provincial Office and local tourism stakeholders. The area is recognized for its high ecological and tourism value, serving as one of the Gulf of Thailand's most popular dive destinations. Land-use planning and zoning designate the pinnacles as marine protected areas (MPAs) where extractive and destructive activities are prohibited. Zoning focuses on separating tourism, navigation, and conservation areas, with anchoring restrictions and mooring buoys installed to protect coral habitats. Institutional framework involves collaboration between DMCR, the Department of National Parks (DNP), and local administrative bodies. These agencies jointly oversee reef monitoring, patrols, and enforcement against illegal fishing and anchoring. Stakeholder coordination includes dive operators, local communities, NGOs, and tourism associations, who actively participate in coral restoration, reef monitoring, and awareness campaigns. Co-management initiatives between

Name of area	Ownership	Management regime
		government and private dive centers have improved compliance with conservation measures. Restoration efforts are ongoing, focusing on coral transplantation, artificial reef installation, and marine debris removal, led by DMCR and local dive networks. Fishery practices are tightly regulated within the marine park boundaries. Destructive fishing is prohibited, and only small-scale traditional fishing is allowed in designated buffer zones.
SG1: Ban Don Bay	State	Ban Don Bay is managed under Surat Thani Province's Integrated Coastal Resource Management Plan, focusing on sustainable fisheries, seagrass conservation, and aquaculture regulation. The Department of Marine and Coastal Resources (DMCR), Department of Fisheries, and Surat Thani Provincial Office are the main agencies responsible for management and enforcement. Land-use planning and coastal zoning divide the bay into aquaculture, fishing, navigation, and conservation zones. However, enforcement remains limited due to overlapping uses, especially between shrimp farming, fishing, and seagrass conservation areas. Increased coordination is needed to balance economic use with ecosystem protection. Institutional framework involves collaboration between DMCR, the Department of Fisheries, local administrative organizations, and community groups. These agencies oversee seagrass monitoring, pollution control, and the management of aquaculture effluents. Stakeholder coordination includes local fishers, aquaculture operators, coastal communities, and conservation networks, though engagement is uneven. Co-management initiatives are developing to promote sustainable fishing and community-based seagrass protection. Restoration activities focus on seagrass replanting, mangrove rehabilitation, and water quality improvement led by DMCR,

Name of area	Ownership	Management regime
		universities, and local communities. These projects aim to restore degraded habitats and support dugong populations. Stakeholder investment is growing, with private aquaculture operators and tourism businesses supporting conservation and water treatment projects. Fishery practices are mostly small-scale and traditional, but illegal trawling and push nets still occur in sensitive areas, causing habitat disturbance. Strengthened enforcement and alternative livelihood programs are needed to reduce pressure on seagrass ecosystems.
SG2: Chumphon	State	Chumphon Province’s coastal and marine resources are managed under the Chumphon Marine National Park and the Department of Marine and Coastal Resources (DMCR), with support from the Chumphon Provincial Office and local administrative organizations. The area includes coral reefs, seagrass meadows, mangroves, and offshore pinnacles of high ecological value. Land-use planning and zoning designate coastal and offshore areas for conservation, fishing, aquaculture, tourism, and navigation. Marine protected areas (MPAs) include underwater pinnacles and coral reef zones, where anchoring and destructive fishing are prohibited. Institutional framework involves cooperation between DMCR, the Department of Fisheries, and local governments. These agencies oversee resource monitoring, enforcement, and restoration programs, ensuring alignment with national marine policies. Stakeholder coordination is improving through participation of local fishers, dive operators, NGOs, and community networks. Co-management initiatives promote sustainable tourism, reef protection, and community-based conservation, especially in areas like Thung Wua Laen and Lang Suan. Restoration activities include coral

Name of area	Ownership	Management regime
		transplantation, seagrass rehabilitation, and artificial reef installation, carried out by DMCR, local universities, and dive centers. Fishery practices are mostly small-scale and traditional, though illegal trawling and push nets occasionally impact seagrass and coral areas. Continuous enforcement and awareness campaigns aim to reduce habitat damage.

Current use, traditional use and potential use

An overview of current, traditional, and potential uses of coral reef and seagrass areas across the Gulf of Thailand underscores the multifunctional value of these ecosystems to both local communities and broader national priorities. Current uses consistently include commercial and subsistence fisheries, critical fishing grounds, tourism, and marine protected areas (MPAs), reflecting their central role in sustaining food security, livelihoods, and economic activities. Traditional uses remain significant, with small-scale coastal fisheries employing traditional fish traps, nets, squid fishing, and seasonal harvesting of reef resources in multiple sites, including Koh Si Chang, Koh Lan, Koh Kood, Koh Mak, Koh Tao, Koh Kra, Koh Losin, the underwater pinnacles in Chumphon Province, Ban Don Bay, and Chumphon. These long-standing practices highlight community dependence on marine biodiversity and the cultural continuity of resource use. Looking forward, potential uses are strongly associated with the expansion of tourism and MPAs across nearly all sites, aligning with national policy directions toward sustainable tourism and biodiversity conservation. Collectively, these findings emphasize the need for integrated management strategies that balance traditional fisheries, emerging tourism opportunities, and conservation objectives to ensure the long-term resilience and multifunctional benefits of coral reef and seagrass ecosystems in the Gulf of Thailand. (Table 15)

Table 15. Coral and seagrass areas in Thailand (Gulf of Thailand): Social and use information showing current use, traditional use and potential use

Name of area	Current use	Traditional use	Potential use
CR:1 Koh Si Chang	**Commercial Use:** The island lies adjacent to Laem Chabang Port, one of Thailand’s busiest industrial and shipping zones. The surrounding waters are used for cargo anchorage, fuel transport, and marine logistics, contributing to regional commerce	Small-scale fisheries; squid fishing and collection of marine invertebrates	**Tourism (Sustainable Use):** Koh Si Chang has strong potential for eco- and cultural tourism development under a sustainable management framework. Its proximity to Bangkok (about 120 km) and coastal heritage make it ideal for day-trip tourism, diving,

Name of area	Current use	Traditional use	Potential use
	but also increasing sedimentation and pollution risks. **Subsistence Use:** Local residents engage in small-scale coastal fishing, seaweed collection, and aquaculture for household consumption and local markets. These activities support community livelihoods but are constrained by industrial expansion and restricted fishing zones. **Fishing Ground:** Traditional fishing areas remain active around the island, mainly using traps and handlines targeting reef fish, squid, and crab. However, fishing zones are shrinking due to maritime traffic and port operations, creating competition for space. **Tourism:** Koh Si Chang is a domestic tourism destination, known for cultural attractions, scenic viewpoints, and limited snorkeling and diving sites. Tourism provides significant income to local communities but is affected by water quality and		snorkeling, and cultural sightseeing. Sustainable tourism planning could focus on: • Promoting low-impact marine recreation such as snorkeling, kayaking, and guided reef interpretation. • Developing community-based tourism to benefit local residents through homestays, traditional food, and eco-tours. • Establishing visitor carrying capacity limits to prevent overuse at sensitive coral sites. • Introducing reef-safe tourism standards, including wastewater treatment and anchoring control for boats. **Marine Protected Area (MPA) Sustainable Use:** Although Koh Si Chang is not currently a formal MPA, it could be integrated into a coastal multiple-use conservation zone under the Department of Marine and Coastal Resources (DMCR).

Name of area	Current use	Traditional use	Potential use
	coastal development. **Marine Protected Area (MPA):** Koh Si Chang is not formally designated as an MPA, but coral reef monitoring and small-scale restoration projects are conducted by the Department of Marine and Coastal Resources (DMCR). Conservation initiatives focus on reducing anchor damage, monitoring reef health, and promoting responsible tourism.		Sustainable use within such a designation could include: • Zoning for conservation and recreation, separating coral habitats from port and industrial zones. • Coral restoration and monitoring areas, with mooring buoys to prevent anchor damage. • Collaborative management involving local communities, dive operators, and Laem Chabang Port authorities. • Establishing a "marine buffer zone" to protect coral reefs located approximately 300–800 meters from the coast from sedimentation and pollution.
CR:2 Koh Lan	**Commercial Use:** The island's economy is driven primarily by tourism-related businesses, including accommodations, restaurants, speedboat operators, and ferry services connecting to Pattaya. Indirect	Local fisheries; use of traditional fish traps	**Tourism (Sustainable Use):** Koh Lan has significant potential to become a model for sustainable coastal and marine tourism in the Gulf of Thailand. With its proximity to Pattaya, the island can shift from high-volume tourism to eco-friendly

Name of area	Current use	Traditional use	Potential use
	commercial activities, such as seafood supply and souvenir trading, also contribute to the local economy. **Subsistence Use:** Some local households engage in small-scale fishing and aquaculture, primarily for family use or local markets. Subsistence practices include crab trapping and squid fishing in nearshore areas. **Fishing Ground:** Koh Lan's surrounding waters serve as traditional fishing grounds, but fishing areas are shrinking due to tourism boat traffic and restricted zones around beaches and piers. Fishing is mainly done with traps and handlines, with no destructive methods reported. **Tourism:** Tourism is the dominant activity on Koh Lan, attracting thousands of domestic and international visitors daily. Major activities include snorkeling, diving, water sports, and beach recreation. High tourism pressure has led to localized coral degradation,		and low-impact tourism by: • Developing zoned tourism areas that separate swimming, snorkeling, and boating zones to reduce reef damage. • Promoting eco-tourism activities such as guided snorkeling, reef interpretation trails, kayaking, and environmental education for visitors. • Implementing visitor capacity limits and reef-safe tourism guidelines to manage overcrowding and reduce pollution. • Encouraging community-based tourism, where local residents provide homestays, sustainable seafood, and cultural experiences to distribute benefits equitably. **Marine Protected Area (MPA) Sustainable Use:**

Name of area	Current use	Traditional use	Potential use
	anchor damage, and wastewater pollution. **Marine Protected Area (MPA):** Koh Lan is not officially designated as an MPA, but coral reefs and coastal zones are under the monitoring and management of the Department of Marine and Coastal Resources (DMCR). Efforts include installing mooring buoys, conducting coral restoration, and promoting eco-tourism awareness.		Koh Lan's coral reef zones could be designated as a multiple-use MPA under the Department of Marine and Coastal Resources (DMCR) to ensure balanced protection and utilization. Sustainable MPA management could include: • Establishing zoning systems for conservation, recreation, and limited fishing areas. • Installing mooring buoys to prevent anchor damage and protect coral structures. • Conducting coral restoration and monitoring programs with support from local dive centers and universities. • Strengthening co-management between DMCR, Pattaya City, and local communities for long-term reef stewardship.
CR:3 Koh Kood	**Commercial Use:** The island's economy is based primarily on eco- and resort-based tourism, with numerous mid- to	Local fisheries; seasonal fishing and harvesting of reef resources	**Tourism (Sustainable Use):** Koh Kood has strong potential to become a flagship model for sustainable marine and coastal tourism in

Name of area	Current use	Traditional use	Potential use
	high-end resorts and supporting services such as restaurants, transport, and diving operations. Commercial activities are regulated to maintain the island's image as a **sustainable tourism destination**. **Subsistence Use:** Local communities depend on small-scale fisheries, coconut and rubber plantations, and aquaculture for household income and consumption. These traditional practices remain important for local livelihoods and cultural heritage. **Fishing Ground:** Surrounding coastal waters serve as traditional fishing grounds, supporting artisanal fishers using traps, nets, and handlines. Fishing pressure is relatively low, and destructive practices are not reported. Some zones are informally managed as community fisheries. **Tourism:** Tourism is the main economic driver, emphasizing eco-friendly and nature-		Thailand. With its clear waters, healthy coral reefs, and low visitor density, the island is ideal for eco-tourism and nature-based recreation. Key opportunities include: • Promoting low-impact tourism activities such as snorkeling, diving, kayaking, and mangrove exploration. • Expanding eco-resorts and homestays with strict wastewater and waste management standards. • Encouraging community-based tourism that provides direct income for local people while protecting natural resources. • Developing reef-friendly tourism certification programs for dive and tour operators. **Marine Protected Area (MPA) Sustainable Use:** Although Koh Kood is not a formal MPA, it can be integrated into a multiple-use marine conservation zone under the Department

Name of area	Current use	Traditional use	Potential use
	based tourism such as snorkeling, diving, kayaking, and coastal sightseeing. Strict building codes and environmental standards are encouraged to preserve coral reefs and seagrass meadows close to the shore. **Marine Protected Area (MPA):** While Koh Kood is not officially designated as an MPA, it lies within a broader marine conservation management zone under the Department of Marine and Coastal Resources (DMCR). Coral reef monitoring, mooring buoy installation, and coral restoration programs are periodically implemented in collaboration with local stakeholders.		of Marine and Coastal Resources (DMCR). Sustainable management could include: • Zoning for conservation, recreation, and fishing, ensuring coral reef areas within 100–300 meters from the coast are protected. • Establishing mooring buoys and no-anchoring zones to prevent coral damage. • Implementing coral restoration and reef monitoring programs involving local schools, resorts, and NGOs. • Enhancing co-management between DMCR, local authorities, and tourism operators to maintain water quality and control development.
CR:4 Koh Mak	**Commercial Use:** The island's economy is primarily tourism-based, featuring boutique resorts, restaurants, dive centers, and small-scale transport services. Koh Mak promotes itself as a	Local fisheries; use of traditional fish traps	**Tourism (Sustainable Use):** Koh Mak has exceptional potential to strengthen its reputation as a low-carbon, eco-tourism island. With clear waters, healthy coral reefs, and active

Name of area	Current use	Traditional use	Potential use
	“low-carbon island”, limiting large-scale infrastructure and heavy industry to protect its natural environment. **Subsistence Use:** Local residents engage in small-scale fisheries, coconut farming, and limited aquaculture, mainly for household consumption and local markets. These practices support community livelihoods without major environmental impact. **Fishing Ground:** Surrounding coastal waters serve as traditional fishing areas, mainly using traps, handlines, and nets. Fishing activity is regulated by community rules to prevent habitat damage, and destructive fishing practices are prohibited. **Tourism:** Tourism is the dominant economic activity, focused on eco-tourism, snorkeling, diving, kayaking, and cultural experiences. The island’s reefs and seagrass beds are major attractions, and visitor numbers are		community participation, it can further develop as a sustainable tourism destination by: • Promoting eco-friendly marine recreation, including snorkeling, kayaking, diving, and mangrove exploration. • Expanding community-based tourism through homestays, local food experiences, and environmental education programs. • Strengthening wastewater and solid waste management systems to maintain the island’s “Green Island” status. • Implementing reef-safe tourism standards and visitor limits to minimize ecological impact on coral reefs located 100–500 meters from the shore. **Marine Protected Area (MPA) Sustainable Use:** Koh Mak’s surrounding

Name of area	Current use	Traditional use	Potential use
	managed to minimize ecological disturbance. **Marine Protected Area (MPA):** While Koh Mak itself is not formally declared as an MPA, its surrounding coral reefs are under the monitoring and management of the Department of Marine and Coastal Resources (DMCR). Collaborative programs with local resorts and dive operators include coral restoration, mooring buoy installation, and marine litter management.		reefs can be designated as a multiple-use marine conservation zone under the Department of Marine and Coastal Resources (DMCR) to ensure balanced ecological protection and economic use. Key sustainable actions include: • Establishing zoning for coral conservation, eco-tourism, and traditional fishing to reduce user conflict. • Installing mooring buoys and designating no-anchor zones to prevent coral breakage. • Supporting community-led coral restoration and monitoring projects in partnership with local resorts and dive centers. • Developing a local marine conservation fund from tourism revenues to sustain reef protection and education programs.
CR:5 Koh Tao	**Commercial Use:** The island’s economy is dominated by	Some small-scale coastal fishing	**Tourism (Sustainable Use):** Koh Tao has strong potential to enhance its

Name of area	Current use	Traditional use	Potential use
	tourism and diving industries, with over 70 dive schools, resorts, restaurants, and transport services. Tourism supports local businesses and employment but also contributes to high wastewater generation and coastal infrastructure expansion. **Subsistence Use:** Some local residents maintain small-scale fishing and aquaculture for household use and local markets, though dependence on these activities has declined with tourism growth. **Fishing Ground:** Traditional fishing grounds surround the island, supporting artisanal fishers who use traps, hook-and-line, and gill nets. Destructive fishing (e.g., cyanide or dynamite) is not reported, and local regulations restrict fishing near coral reef areas and dive sites. **Tourism:** Tourism is the primary use of Koh Tao's coastal and marine environment. Activities include		role as a leading sustainable dive and eco-tourism destination in the Gulf of Thailand. Its coral reefs, located within 50–300 meters of the shore, are central to its tourism economy and can be managed through responsible practices, such as: • Expanding eco-certification programs for dive operators and resorts (e.g., Green Fins, Blue Flag). • Promoting low-impact marine activities like guided snorkeling, reef restoration diving, and marine ecology education for visitors. • Implementing tourism carrying capacity limits and strengthening wastewater treatment to prevent nutrient pollution. • Encouraging community-based tourism that integrates conservation education, local livelihoods, and cultural heritage. **Marine Protected**

Name of area	Current use	Traditional use	Potential use
	diving, snorkeling, kayaking, and eco-tourism, attracting both domestic and international visitors. However, high tourist density has caused pressure on reef ecosystems, wastewater systems, and beach environments. **Marine Protected Area (MPA):** While Koh Tao is not officially designated as an MPA, several reef areas are under DMCR and community co-management for coral restoration, mooring buoy maintenance, and reef monitoring. Community-driven conservation programs, led by local NGOs and dive operators, function as de facto marine protection zones.		**Area (MPA) — Sustainable Use:** While Koh Tao is not yet a formal MPA, it could be designated as a community-managed multiple-use conservation area under the Department of Marine and Coastal Resources (DMCR) framework. Sustainable management actions may include: • Zoning for coral conservation, recreation, and limited fishing, ensuring reef resilience. • Installing mooring buoys and no-anchor zones to protect coral habitats. • Expanding coral nurseries, reef restoration, and citizen-science monitoring involving dive operators and NGOs. • Strengthening co-management between DMCR, local government, and tourism associations to balance economic use and ecological protection.
CR:6 Koh Kra	**Commercial Use:** There is no commercial or	Coastal fisheries and small-scale coastal fishing	**Tourism (Sustainable Use):** Koh Kra has limited but

Name of area	Current use	Traditional use	Potential use
	industrial activity permitted at Koh Kra. The area is protected from coastal development and industrial operations due to its isolation (approximately 70 km from Nakhon Si Thammarat Province). **Subsistence Use:** No permanent residents live on the island. Occasional visits by local fishers occur for temporary shelter or subsistence fishing under strict control, but activities are minimal and regulated by the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy. **Fishing Ground:** The waters surrounding Koh Kra are occasionally used by small-scale traditional fishers, mainly targeting pelagic fish species using non-destructive gear. Commercial and destructive fishing practices are prohibited, with regular patrols ensuring compliance. **Tourism:** Koh Kra is not a		valuable potential for controlled eco-tourism and scientific tourism due to its remote location and pristine coral ecosystems. Any tourism development should be strictly regulated to protect its high biodiversity and ecological integrity. Potential sustainable uses include: • Allowing small-scale, research-based eco-tours under permit, emphasizing education, marine ecology, and conservation awareness. • Developing scientific diving and marine biodiversity observation programs led by universities or conservation groups. • Establishing visitor restrictions and seasonal access limits to prevent coral damage and wildlife disturbance. • Using eco-certification and carrying capacity guidelines to ensure minimal

Name of area	Current use	Traditional use	Potential use
	tourist destination, as access is restricted to protect its coral reefs and marine biodiversity. Only scientific researchers and authorized personnel are permitted to visit for ecological monitoring and conservation purposes. **Marine Protected Area (MPA):** Koh Kra is part of a strict marine conservation zone managed by the DMCR and the Royal Thai Navy. It functions as a natural reference site for coral reef health in the Gulf of Thailand, supporting high coral cover (40–70%) and rich marine biodiversity.		ecological footprint. **Marine Protected Area (MPA) Sustainable Use:** Koh Kra already functions as a strict marine conservation zone under the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy. Its potential lies in strengthening this protection through a formal multiple-use MPA framework that supports limited, sustainable research and education activities while maintaining full ecological protection. Recommended measures include: • Defining zoning for strict protection and scientific access only. • Maintaining no-take and no-anchor zones to protect coral reefs and nesting beaches. • Enhancing long-term coral monitoring, restoration, and biodiversity assessment through national and academic partnerships.

Name of area	Current use	Traditional use	Potential use
			• Developing a national reference site for coral reef resilience and climate change studies.
CR:7 Koh Losin	**Commercial Use:** There is no commercial or industrial use at Koh Losin. The site is far from coastal settlements (approximately 72 km from Pattani Province) and is protected from development and industrial exploitation. **Subsistence Use:** There are no permanent inhabitants on Koh Losin. Occasional visits by small-scale traditional fishers may occur, but activities are minimal and closely monitored by the Royal Thai Navy to prevent illegal fishing or harvesting. **Fishing Ground:** Surrounding waters were historically part of traditional fishing routes, but fishing is now strictly restricted or prohibited within the conservation boundary. The area serves primarily as a no-take zone for coral reef protection,	Coastal fisheries and small-scale coastal fishing	**Tourism (Sustainable Use):** Koh Losin has exceptional potential for specialized eco-tourism and scientific diving due to its remote location, outstanding coral reef condition, and rich biodiversity. Because of strong currents and limited accessibility, tourism use must remain strictly controlled and small-scale. Potential sustainable uses include: • Promoting scientific and conservation-focused diving expeditions under special permits. • Developing marine research tourism in partnership with universities and conservation organizations. • Allowing limited eco-tourism visits focused on education, photography, and coral monitoring, with strict environmental

Name of area	Current use	Traditional use	Potential use
	with occasional patrols and ecological assessments conducted by the Department of Marine and Coastal Resources (DMCR). **Tourism:** Koh Losin is not a tourist destination due to its remote location and strong currents. Access is limited to researchers, conservation teams, and authorized diving expeditions operating under special permits. **Marine Protected Area (MPA):** Koh Losin functions as a strict marine conservation zone managed by the DMCR and the Royal Thai Navy, serving as a reference site for coral reef health in the Gulf of Thailand. It features high coral cover (50–80%), excellent water clarity, and diverse coral and fish assemblages.		guidelines and carrying capacity limits. • Establishing reef-safe mooring systems and waste-free regulations for all permitted vessels. **Marine Protected Area (MPA) Sustainable Use:** Koh Losin already serves as a strict marine conservation zone under the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy. Its potential lies in being officially designated as a no-take multiple-use MPA and a national marine research reference site. Sustainable management measures should include: • Formalizing zoning for conservation, research, and controlled visitation. • Expanding coral reef and pelagic species monitoring programs with long-term data collection. • Maintaining no-anchor and no-fishing zones

Name of area	Current use	Traditional use	Potential use
			through continuous naval patrols. • Establishing Koh Losin as a marine biodiversity and climate resilience benchmark site for the Gulf of Thailand.
CR:8 Underwater pinnacle Chumphon Province	**Commercial Use:** There is no large-scale commercial or industrial use at the pinnacles. However, nearby Chumphon City (about 15–25 km away) supports small ports and aquaculture operations, which can indirectly influence water quality through runoff and vessel activity. **Subsistence Use:** Local communities engage in small-scale coastal fishing around Chumphon's nearshore waters, but fishing activity around the offshore pinnacles is minimal due to depth and distance. These sites are primarily valued for tourism and conservation rather than subsistence resource use. **Fishing Ground:** Fishing is restricted within the	Coastal fisheries and small-scale coastal fishing	**Tourism (Sustainable Use):** The underwater pinnacles in Chumphon Province have outstanding potential for sustainable dive and eco-tourism, given their high coral diversity, clear waters, and accessibility. Key sustainable tourism opportunities include: • Developing eco-friendly diving and snorkeling zones, with strict carrying capacity limits and reef-safe practices. • Promoting marine eco-tourism packages that include coral conservation education, guided reef tours, and citizen-science participation. • Strengthening tourism management

Name of area	Current use	Traditional use	Potential use
	designated Chumphon Marine National Park area, which includes several of the underwater pinnacles. Small-scale fishing using traps and lines may occur in buffer zones, but destructive practices such as trawling and dynamite fishing are strictly prohibited. **Tourism:** Tourism is the primary activity, centered on diving and snorkeling. The pinnacles, such as Hin Lak Ngam and Hin Phae, are famous for their diverse coral reefs and abundant marine life, attracting both domestic and international dive operators. Tourism provides local economic benefits but also requires careful management to prevent anchor damage and diver-induced stress. **Marine Protected Area (MPA):** The underwater pinnacles are located within the Chumphon Marine National Park, managed by the Department of Marine and Coastal		guidelines to minimize anchor damage and diver impacts. • Expanding community-based tourism that benefits local operators, dive schools, and fishing communities. **Marine Protected Area (MPA) Sustainable Use:** The pinnacles are already within the Chumphon Marine National Park, providing a strong foundation for sustainable multiple-use MPA management. Potential enhancements include: • Establishing zoning plans that balance conservation, tourism, and limited fishing. • Installing additional mooring buoys and no-anchor zones to protect coral structures. • Expanding coral restoration programs and reef monitoring in collaboration with dive centers, DMCR, and research institutions. • Encouraging co-management

Name of area	Current use	Traditional use	Potential use
	Resources (DMCR) and the Department of National Parks (DNP). These areas are under formal protection, with ongoing reef monitoring, coral restoration, and installation of mooring buoys to reduce physical damage.		frameworks between local authorities, private tourism operators, and conservation organizations to ensure long-term reef protection.
SG1: Ban Don Bay	**Commercial Use:** The bay is an important center for aquaculture and coastal fisheries, particularly shrimp, crab, and shellfish farming. Small-scale seafood processing and local transport activities also contribute to the commercial economy. Coastal industries and port facilities near Surat Thani City (about 5–15 km from the bay) influence water quality and sediment load. **Subsistence Use:** Local communities depend heavily on small-scale fishing, aquaculture, and gleaning of shellfish and seaweed for household consumption and income. These traditional activities remain vital for local livelihoods. **Fishing Ground:**	Coastal fisheries and small-scale coastal fishing	**Tourism (Sustainable Use):** Ban Don Bay has strong potential for eco-tourism and community-based nature tourism centered around its extensive seagrass meadows, mangrove forests, and dugong habitats. Sustainable tourism opportunities include: • Developing eco-tours such as birdwatching, dugong observation, and mangrove kayaking. • Promoting community-based tourism programs that engage local fishers and aquaculture farmers as eco-guides. • Creating environmental education and interpretation centers focusing

Name of area	Current use	Traditional use	Potential use
	Ban Don Bay serves as one of the most productive fishing grounds in the Gulf of Thailand, supporting a wide range of artisanal fishing practices such as traps, gill nets, and push nets. However, illegal trawling and habitat disturbance still occur in some areas, threatening seagrass and benthic habitats. **Tourism:** Tourism is limited but growing, focusing on eco-tourism and community-based activities, such as birdwatching, mangrove trails, and dugong-watching tours. Sustainable tourism initiatives aim to raise awareness of seagrass conservation. **Marine Protected Area (MPA):** Although Ban Don Bay is not formally designated as a Marine Protected Area, it is recognized by the Department of Marine and Coastal Resources (DMCR) as a critical habitat for seagrass, dugongs, and coastal biodiversity.		on seagrass conservation and blue carbon ecosystems. • Implementing visitor capacity management and eco-certification for tour operators to ensure minimal disturbance to sensitive habitats. **Marine Protected Area (MPA) Sustainable Use:** Although Ban Don Bay is not yet formally designated as an MPA, it could be established as a multiple-use coastal conservation area under the Department of Marine and Coastal Resources (DMCR) framework. Sustainable management actions could include: • Zoning to separate conservation, fishing, aquaculture, and tourism areas. • Establishing no-take zones in key seagrass meadows critical for dugongs and juvenile fish. • Expanding seagrass and mangrove

Name of area	Current use	Traditional use	Potential use
	Restoration and monitoring programs are ongoing in collaboration with local universities and communities.		restoration programs involving local communities and universities. • Strengthening co-management among DMCR, the Department of Fisheries, and local administrative organizations to ensure integrated coastal management.
SG2: Chumphon	**Commercial Use:** The coastal zone supports aquaculture (shrimp, fish, and shellfish farms) and small-scale seafood processing industries. Commercial ports and fish landing sites in Chumphon City facilitate marine transport and local trade. Offshore areas, including underwater pinnacles, contribute to marine tourism and diving industries that generate significant income for the province. **Subsistence Use:** Coastal communities rely on small-scale fishing, aquaculture, and mangrove resource use for household consumption and	Coastal fisheries and small-scale coastal fishing	Tourism (Sustainable Use): Chumphon's extensive seagrass meadows have potential for eco-tourism and environmental education focused on blue carbon ecosystems and coastal biodiversity. Sustainable uses include: • Developing eco-tours and educational trails highlighting the role of seagrass in carbon storage, fish nurseries, and dugong feeding grounds. • Promoting community-based eco-tourism such as seagrass observation by kayak,

Name of area	Current use	Traditional use	Potential use
	local markets. These activities are vital for food security and income, particularly in Tha Sae, Pathio, and Lang Suan Districts. **Fishing Ground:** Chumphon's coastal and offshore waters are important traditional fishing grounds, supporting trap, gill net, and handline fisheries targeting fish, squid, and crab. Some buffer zones within the Chumphon Marine National Park restrict destructive fishing practices to protect coral reefs and seagrass meadows. **Tourism:** Tourism is a growing sector, focusing on eco-tourism, snorkeling, diving, and island visits. Sites such as Thung Wua Laen Beach, Koh Ngam Yai, Koh Ngam Noi, and the underwater pinnacles are major attractions. Tourism activities are managed to reduce anchor damage and promote sustainable marine recreation. **Marine Protected Area (MPA):** Several marine zones, including the Chumphon Marine		birdwatching, and coastal conservation volunteering. • Establishing interpretive centers or learning hubs on seagrass ecology and blue carbon value for students and tourists. **Marine Protected Area (MPA) Sustainable Use:** Chumphon's seagrass meadows can be incorporated into multiple-use conservation zones within the Chumphon Marine National Park and under DMCR management. Sustainable MPA management could include: • Zoning to balance seagrass conservation, small-scale fishing, and eco-tourism. • Implementing no-trawl and no-anchor zones to protect fragile seagrass habitats. • Expanding community-led restoration and monitoring programs with participation

Name of area	Current use	Traditional use	Potential use
	National Park, are under the management of the Department of Marine and Coastal Resources (DMCR) and the Department of National Parks (DNP). These MPAs protect coral reefs, seagrass beds, and mangroves through monitoring, coral restoration, and mooring buoy installation.		from local schools, fishers, and conservation groups. • Strengthening co-management frameworks among DMCR, local government, and communities to ensure long-term protection.

Significance/national importance and protection status

All coral reef and seagrass areas in the Gulf of Thailand are under state jurisdiction and hold high national significance for biodiversity conservation, blue carbon functions, and sustainable development. Managed primarily by the Department of Marine and Coastal Resources (DMCR), with collaboration from provincial authorities, the Department of National Parks (DNP), and the Royal Thai Navy, these sites collectively represent Thailand's key marine ecosystems and policy priorities. Koh Si Chang and Koh Lan serve as pilot sites for Marine Spatial Planning (MSP), while Koh Kood and Koh Mak are recognized as models for eco-tourism and sustainable island management within the Eastern Marine Conservation Network. Koh Tao functions as a leading site for coral reef restoration and community-based tourism, supporting Thailand's blue economy. Offshore sites such as Koh Kra and Koh Losin possess exceptional biodiversity value and serve as reference areas for coral health monitoring and climate change studies. The underwater pinnacles in Chumphon Province are important for coral diversity and dive tourism, while Ban Don Bay and the seagrass meadows along Chumphon's coast are vital blue carbon ecosystems that support dugongs, sea turtles, and juvenile fish. Protection designations vary across sites, ranging from formal status such as the Mu Ko Chang National Park (Koh Kood), the Ramsar Site (Koh Kra), and the Chumphon Marine National Park to local conservation frameworks under DMCR's coastal zoning. Collectively, these areas illustrate Thailand's integrated approach to marine resource management, combining ecosystem-based conservation, community participation, and sustainable use to enhance marine biodiversity protection, climate resilience, and long-term blue economy development. (Table 16)

Table 16. Coral and seagrass areas in Thailand (Gulf of Thailand): Social and use information showing significance/national importance and protection status

Name of area	Significance/national importance	Protection status
CR:1 Koh Si Chang	Koh Si Chang holds national significance as a pilot site for	**Status / Protection category:**

	Marine Spatial Planning (MSP) under Thailand's coastal and marine management strategy led by the Department of Marine and Coastal Resources (DMCR). It serves as a model for integrating marine zoning, sustainable use, and stakeholder coordination within a complex multi-use area influenced by tourism, fisheries, and nearby industrial development (Laem Chabang Port). In national and provincial master plans, Koh Si Chang is designated for multi-purpose use, including tourism, transport, fisheries, and environmental conservation, making it a strategic case for balancing economic development with marine ecosystem protection. Its inclusion in Thailand's MSP framework and coastal management plans underscores its importance as a demonstration site for sustainable coastal governance and resource management in the Gulf of Thailand.	Not designated as a National Park or formal MPA. Managed under DMCR coastal-marine measures and used as a pilot area for Marine Spatial Planning (MSP); local protections apply via DMCR regulatory orders. **Total area:** 17.3 km² (Ko Sichang district, incl. main island and adjoining islets).
CR:2 Koh Lan	Koh Lan is of national and regional importance as part of Thailand's Eastern Economic Corridor (EEC) coastal zone, identified in national and provincial development plans for tourism and coastal resource management. The island supports large-scale tourism from Pattaya and serves as a key example of balancing economic growth with marine ecosystem protection. In national and provincial master plans, Koh Lan is designated as a high-priority	**Status / Protection category:** There is no formal Marine Protected Area (MPA) or National Park status covering Koh Lan's surrounding waters. However, the island's marine and coastal zones have been identified under national pilot projects for marine spatial planning and protected-area zoning. For example, the island is a case study for MSP by the Department of Marine and Coastal Resources (DMCR).

	tourism and environmental management area under the Chonburi Provincial Coastal Strategy and the Department of Marine and Coastal Resources (DMCR). It is recognized as a sensitive marine zone requiring strict control on wastewater, sedimentation, and coral reef conservation.	**Total area:** Approximately 5.6 km² (~560 hectares) for the island land area.
CR:3 Koh Kood	Koh Kood holds national significance as a key island within Trat Province's coastal and marine resource management plan and Thailand's National Marine and Coastal Resources Master Plan. It is identified as a priority site for sustainable tourism development and marine ecosystem conservation, emphasizing the protection of coral reefs, seagrass meadows, and mangroves. The island is included in the Eastern Marine Conservation Network and aligned with national strategies promoting eco-tourism, biodiversity conservation, and blue economy development. Koh Kood's zoning under the Department of Marine and Coastal Resources (DMCR) designates areas for tourism, small-scale fisheries, and marine conservation, making it a model for balanced, low-impact island management.	**Status / Protection category:** Koh Kood lies within the broader management domain of the Mu Ko Chang National Park region (IUCN Category II) and is subject to oversight by the Department of Marine and Coastal Resources (DMCR). **Total area:** The island of Koh Kood covers approximately **~**105 km² (10,500 hectares) (it is Thailand's 5th-largest island).
CR:4 Koh Mak	Koh Mak is nationally recognized as a model for sustainable island development and low-carbon tourism under Thailand's National Marine and Coastal Resources Master Plan and Trat Province's Coastal Development Strategy. It has been designated as one of Thailand's "Low-Carbon and Sustainable Tourism Pilot	**Status / Protection category:** Koh Mak is not designated as a formal Marine Protected Area (MPA) or National Park. Instead, it is managed under local sustainable tourism and conservation initiatives, including community-based low-carbon island programmes and the

	Islands" by the Designated Areas for Sustainable Tourism Administration (DASTA) and supported by the Department of Marine and Coastal Resources (DMCR) for marine conservation. The island is part of the Eastern Marine Conservation and Tourism Network, linking conservation efforts across Koh Chang, Koh Kood, and nearby islands. Its land-use and marine zoning emphasize eco-tourism, community participation, and coral reef protection, serving as a national model for integrating tourism with environmental stewardship.	oversight of the Department of Marine and Coastal Resources (DMCR). **Total area:** The island covers approximately 12.3 km² (~1,230 hectares) according to marine tourism/ecotourism sources.
CR:5 Koh Tao	Koh Tao holds national significance as one of Thailand's premier marine eco-tourism and coral reef conservation sites. It is recognized in the National Marine and Coastal Resources Master Plan and Surat Thani Province's Coastal Development Strategy as a key area for sustainable tourism, coral reef restoration, and community-based resource management. The island contributes significantly to Thailand's blue economy and eco-tourism sector, being one of the country's most important dive tourism destinations and a model for local participation in marine conservation. It also supports national biodiversity and climate goals through coral reef rehabilitation and environmental education programs under the Department of Marine and Coastal Resources (DMCR).	**Status / Protection category:** Koh Tao is *not* formally designated as a national park or full MPA. However, there is a **local marine zoning plan** and **conservation regulations** applied under the Department of Marine and Coastal Resources (DMCR) and local municipality. **Total area:** The island covers approximately 21 km² (~2,100 hectares).
CR:6 Koh Kra	Koh Kra is nationally important	**Status / Protection**

	as a high-value conservation site, recognized under Thailand's marine policy frameworks for its exceptional coral reef ecosystems and low-impact human use. It is integrated into national priorities via: • Formal designation as a strict marine conservation zone, managed by the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy, which underscores its role in national biodiversity protection and reef resilience. • Serving as a reference site for coral reef health in the Gulf of Thailand, allowing national monitoring of coral ecosystem status away from intense coastal development. • Being part of Thailand's blue-economy and coastal management vision, highlighting the value of offshore, low-impact islands for conservation and marine habitat integrity.	**category:** The Koh Kra Archipelago is designated as a Ramsar site (Wetland of International Importance) since 12 August 2013. It is also managed as a marine conservation zone under the oversight of the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy, with strict regulations on fishing and access. **Total area:** The official Ramsar site area is 374 hectares for the Koh Kra Archipelago.
CR:7 Koh Losin	Koh Losin holds national significance as one of Thailand's most pristine offshore coral reef ecosystems and a priority marine conservation site under the Department of Marine and Coastal Resources (DMCR) and the Royal Thai Navy. It serves as a national reference site for coral reef health and biodiversity monitoring in the southern Gulf of Thailand, representing nearly	**Status / Protection category:** The Thai government has approved a draft ministerial regulation to declare Koh Losin (in Panare District, Pattani Province) a "Marine and Coastal Resources Protected Area" under the Marine and Coastal Resources Management Act B.E. 2558. **Total area:** A precise total area (land + marine) for the formal protected zone is not

	undisturbed marine conditions. The area is recognized in the National Marine and Coastal Resources Master Plan as a strict conservation zone due to its high coral cover (50–80%), excellent water clarity, and ecological role as a habitat for reef fish, pelagic species, and coral reef regeneration. Its remoteness and protection status make it an important site for scientific research, biodiversity assessment, and climate change monitoring.	yet published. Koh Losin itself is extremely small (above-water rock ~100 m²) and the surrounding reef area extends offshore.
CR:8 Underwater pinnacle Chumphon Province	The underwater pinnacles in Chumphon Province hold national significance as part of Thailand's Marine Protected Area (MPA) network and are managed under the Chumphon Marine National Park by the Department of National Parks (DNP) and the Department of Marine and Coastal Resources (DMCR). These sites represent some of the most biologically diverse coral reef ecosystems in the Gulf of Thailand. In Thailand's National Marine and Coastal Resources Master Plan, the area is recognized for its dual importance: • Ecological value, serving as a key coral reef biodiversity hotspot and fish spawning ground. • Economic value, as a leading eco-dive tourism destination supporting sustainable livelihoods and regional blue economy growth. The pinnacles also serve as a national reference site for coral monitoring and reef restoration, aligned with Thailand's strategies for marine biodiversity conservation,	**Status / Protection category:** The underwater pinnacles of Chumphon Province fall within the Chumphon Marine National Park and are managed under the oversight of the Department of Marine and Coastal Resources (DMCR) and the Department of National Parks, Wildlife and Plant Conservation (DNP). **Total area:** Specific total area for just the pinnacles is not publicly specified; the broader marine park area covers thousands of hectares encompassing numerous islands, reefs and seascapes.

	climate adaptation, and sustainable tourism.	
SG1: Ban Don Bay	Ban Don Bay holds high national significance as one of Thailand's most important coastal and estuarine ecosystems, recognized in the National Marine and Coastal Resources Master Plan and the Surat Thani Provincial Coastal Management Strategy. The bay supports extensive seagrass meadows, mangrove forests, and mudflats, which serve as critical habitats for dugongs, sea turtles, and juvenile fish species. The area is designated as a priority conservation and blue carbon site under the Department of Marine and Coastal Resources (DMCR), reflecting its importance for carbon sequestration, biodiversity conservation, and sustainable fisheries. It also contributes to Thailand's Nationally Determined Contribution (NDC) targets for climate mitigation through coastal ecosystem restoration. In national and provincial master plans, Ban Don Bay is identified as a multi-use coastal zone—balancing fisheries, aquaculture, and conservation—and as a pilot area for community-based seagrass protection and blue economy development.	**Status / Protection category:** Not formally declared as a full Marine Protected Area (MPA) or National Park, but recognized as a **priority conservation area** under the Department of Marine and Coastal Resources (DMCR) for its extensive seagrass meadows and dugong habitat. **Total area:** The bay extends along the Gulf of Thailand coast in Surat Thani Province, with a coastline of about 100 km and shallow bays dominated by estuaries of the Tapi and Phum Duang rivers.
SG2: Chumphon	Chumphon Province holds national significance for its extensive seagrass meadows, which are recognized under Thailand's National Marine and Coastal Resources Master Plan and managed by the Department of Marine and Coastal Resources (DMCR). The province's coastal zones	**Status / Protection category:** The seagrass meadows along the coast of Chumphon Province fall under the jurisdiction of the Department of Marine and Coastal Resources (DMCR) and are partially located within protected zones such

	especially Tha Sae, Pathio, and Lang Suan Districts contain large, productive seagrass beds that provide critical habitats for dugongs, sea turtles, and juvenile fish species. In national and provincial frameworks, Chumphon is designated as a priority area for blue carbon conservation, contributing to Thailand's Nationally Determined Contribution (NDC) on climate change mitigation. The seagrass meadows act as major carbon sinks and are included in national programs for blue carbon ecosystem assessment and restoration. Chumphon is also recognized as a key site for community-based coastal management, where local stakeholders, universities, and DMCR collaborate on seagrass monitoring, restoration, and sustainable fisheries.	as the Mu Ko Chumphon National Park (IUCN Category II). The status is multiple-use managed habitat rather than strictly no-take. **Total area:** The seagrass meadows are estimated to cover ~8,000–10,000 hectares in Chumphon coastal and estuarine zones (as per regional surveys).

Coverage of hard coral and seagrass

An assessment of hard coral and seagrass coverage across coral reef areas in the Gulf of Thailand reveals considerable spatial variation in ecosystem condition. The highest recorded hard coral cover occurs at Koh Losin (69.50%), followed by Koh Tao (61.27%) and Koh Kra (59.52%), indicating relatively well-developed and structurally complex reef communities at offshore and less disturbed sites. Moderate coral cover is reported from Koh Lan (39.50%) and Koh Kood (33.45%), while lower levels are observed at Koh Mak (29.69%) and Koh Si Chang (29.24%), reflecting signs of degradation or limited recovery capacity in nearshore areas under higher human pressure. The underwater pinnacles in Chumphon Province exhibit moderate coral cover (31.11%), suggesting developing reef communities influenced by hydrodynamic conditions and localized management practices. In contrast to coral reefs, seagrass distribution is concentrated in specific sites, with Ban Don Bay (30.00%) and Chumphon (27.00%) showing substantial meadow coverage, underscoring their role as essential habitats for fisheries, coastal protection, and biodiversity support. Other surveyed reef areas reported no significant seagrass presence, highlighting clear habitat specialization between coral- and seagrass-dominated systems. This variability in coral and seagrass coverage across the Gulf of Thailand emphasizes the importance of site-specific monitoring and targeted conservation measures to address localized threats, strengthen resilience, and ensure the long-term persistence of these critical coastal ecosystems. (Table 17)

Table 17. Coral and seagrass areas in Thailand (Gulf of Thailand): Biological data showing coverage of hard coral

Name of area	**Coverage**	
	Coverage of hard coral (%)	**Coverage of seagrass (%)**
CR:1 Koh Si Chang	29.24	-
CR:2 Koh Lan	39.50	-
CR:3 Koh Kood	33.45	-
CR:4 Koh Mak	29.69	-
CR:5 Koh Tao	61.27	-
CR:6 Koh Kra	59.52	-
CR:7 Koh Losin	69.50	-
CR:8 Underwater pinnacle Chumphon Province	31.11	-
SG1: Ban Don Bay	-	30.00
SG2: Chumphon	-	27.00

SCS endemic species and endangered of threatened species (IUCN)

An assessment of endemic coral species and the presence of internationally recognized threatened taxa across the Gulf of Thailand highlights the exceptional conservation value of its coral reef ecosystems. The region supports a diverse assemblage of South China Sea endemic species, including *Pectinia lactuca*, *Turbinaria patula*, *Acropora microclados*, *Merulina ampliata*, *Echinopora lamellose*, and several *Pectinia* and *Goniopora* species. Coral communities also harbor numerous taxa classified under the IUCN Red List as Endangered (EN), such as *Pectinia lactuca*, along with multiple Vulnerable (VU) species within the genus *Acropora*, including *A. humilis*, *A. muricata*, *A. millepora*, and *A. hyacinthus*. Additional species are considered Near Threatened (NT), notably *Favia favus*, *Galaxea fascicularis*, *Porites lutea*, and *Heliopora coerulea* (blue coral), reflecting broader regional declines in coral abundance and habitat integrity. The distribution of these species underscores spatial variability in biodiversity and indicates the need for continued surveys. Collectively, these findings reinforce the importance of prioritizing conservation and targeted management interventions in areas of high endemism and vulnerability to ensure the long-term persistence of ecologically and economically significant coral reef species. (Table 18)

Table 18. Coral and seagrass areas in Thailand (Gulf of Thailand): Biological data showing SCS endemic species and endangered of threatened species (IUCN)

Name of area	**SCS Endemic species**	**Endangered of threatened species (IUCN)**
CR:1 Koh Si Chang **CR:2 Koh Lan** **CR:3 Koh Kood,** **CR:4 Koh Mak**	- *Pectinia Lactuca* - *Turbinaria patula* - *Acropora microclados*	Endangered (EN) *Pectinia Lactuca* Vulnerable (VU *Acropora humilis*, *Acropora muricata*, *Acropora millepora,*

Name of area	SCS Endemic species	Endangered of threatened species (IUCN)
CR:5 Koh Tao CR:6 Koh Kra CR:7 Koh Losin CR:8 Underwater pinnacle Chumphon Province	- *Merulina ampliata* - *Echinopora lamellose* - *Pectinia Paeonia* - *Pectinia maxima* - *Goniopora stokesi*	*Acropora hyacinthus*, *Acropora nasuta*, *Acropora gemmifera*, *Acropora tenuis*, *Acropora robusta Acropora loripes Montipora foliosa Montipora digitata*, *Montipora aequituberculata*, *Montipora monasteriata*, *Pocillopora acuta*, *Turbinaria patula*, *Turbinaria mesenterina*, *Hydnophora rigida*, *Echinopora lamellose*,*Merulina ampliata* Near Threatened (NT) *Favia favus*, *Favites abdita*, *Platygyra daedalea*, *Goniastrea retiformis*, *Galaxea fascicularis*, *Pavona cactus*, *Fungia fungites*, *Herpolitha limax*, *Ctenactis echinata*, *Porites lutea*, *Porites cylindrica*, *Goniopora stokesi*, *Heliopora coerulea* (Blue coral)
SG1: Ban Don Bay	-	
SG2: Chumphon	-	

Source & sink of larvae and migratory species

An assessment of the biological significance of coral reef areas across the Gulf of Thailand highlights their role as critical habitats for numerous migratory marine species of ecological and conservation concern. Although no sites reported specific data on the source and sink dynamics of coral reef larvae, multiple areas support important migratory taxa. Hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) are consistently recorded from Koh Si Chang, Koh Lan, Koh Kood, Koh Mak, Koh Tao, and Koh Losin, underscoring the importance of these reef habitats as foraging and transit areas. Indian mackerel (*Rastrelliger kanagurta*) are observed across nearly all sites, while mackerel tuna (*Euthynnus affinis*) are particularly associated with Koh Tao and Koh Kra. Notably, whale sharks (*Rhincodon typus*) and bottlenose dolphins (*Tursiops truncatus*) are reported from Koh Tao, alongside records of false killer whales (*Pseudorca crassidens*) at Koh Mak. The occurrence of such large pelagic species illustrates the ecological productivity of these reef ecosystems and their role in sustaining higher trophic levels. The regular use of reef habitats by marine turtles further reinforces the Gulf's contribution to global conservation priorities under international frameworks. At the same time, these ecosystems hold considerable socio-economic value, supporting fisheries and ecotourism that depend on the persistence of migratory populations. Effective management must therefore balance biodiversity protection with sustainable use by coastal communities. Strengthened monitoring of larval dispersal, migratory connectivity, and population trends is essential to inform adaptive strategies and ensure the long-term resilience of coral reef ecosystems under the combined pressures of climate change and coastal development. (Table 19)

Table 19. Coral and seagrass areas in Thailand (Gulf of Thailand): Biological data showing source & sink of larvae and migratory species

Name of area	Source & sink of larvae	Migratory species
CR:1 Koh Si Chang	-	Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*), Indian mackerel (*Rastrelliger kanagurta*)
CR:2 Koh Lan	-	Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*), Indian mackerel (*Rastrelliger kanagurta*)
CR:3 Koh Kood	-	Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*), Indian mackerel (*Rastrelliger kanagurta*)
CR:4 Koh Mak	-	Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*), Indian mackerel (*Rastrelliger kanagurta*) , False Killer Whale (*Pseudorca crassidens*)
CR:5 Koh Tao	-	Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*), Indian mackerel (*Rastrelliger kanagurta*), Mackerel tuna (*Euthynnus affinis*), Whale shark (*Rhincodon typus*), Bottlenose dolphin (*Tursiops truncatus*)-
CR:6 Koh Kra	-	Indian mackerel (*Rastrelliger kanagurta*), Mackerel tuna (*Euthynnus affinis*)-
CR:7 Koh Losin	-	Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*), Indian mackerel (*Rastrelliger kanagurta*), whale shark (*Rhincodon typus*)
CR:8 Underwater pinnacle Chumphon Province	-	Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*), Indian mackerel (*Rastrelliger kanagurta*), whale shark (*Rhincodon typus*)
SG1: Ban Don Bay	-	-
SG2: Chumphon	-	-

- **Economic Valuation (based on Barbier, 1997)**

Economic value of coral reefs in the Gulf of Thailand

An economic assessment of coral reef ecosystems along the Gulf of Thailand underscores their substantial contribution to provincial economies, with considerable variability in estimated annual values across regions. Surat Thani Province demonstrates the highest economic valuation, estimated between 2,500 and 3,500 million THB per year, reflecting its extensive reef resources and robust tourism and fisheries industries. Chon Buri Province also generates significant economic benefits, valued at approximately 1,500 to 2,000 million THB annually. Other provinces with notable contributions include Chumphon (600–800 million THB), Trat (500–700 million THB), and Rayong (400–600 million THB), all of which benefit from well-developed reef-related economic activities. In contrast, Prachuap Khiri Khan and Chanthaburi provinces exhibit more moderate valuations, ranging from 200 to 400 million THB per year. Southern provinces such as Nakhon Si Thammarat, Songkhla, Narathiwat, and Pattani record the lowest estimates, with annual values between 30 and 100 million THB, consistent with smaller reef areas and less intensive commercial use. These findings illustrate the critical economic role of coral reef ecosystems in sustaining coastal livelihoods and regional development, while highlighting the importance of effective conservation and management to preserve their long-term value. (Table 20)

Table 20. Economic value of coral reefs in the Gulf of Thailand (Million THB/year)

Name of area	Economic valuation (Million THB/year)
CR:1 Koh Si Chang	40 million THB
CR:2 Koh Lan	400 million THB
CR:3 Koh Kood	40 million THB
CR:4 Koh Mak	50 million THB
CR:5 Koh Tao	100 million THB
CR:6 Koh Kra	2 million THB
CR:7 Koh Losin	1 million THB
CR:8 Underwater pinnacle Chumphon Province	10 million THB
SG1: Ban Don Bay	
SG2: Chumphon	

Annex III: Fisheries

Appendix Table 1 Annual catch from marine fisheries in the Gulf of Thailand between 1971 and 2023 (unit: metric tonne)

Species groups	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Demersal fishes	353,684	594,153	666,701	464,307	596,602	645,500	739,642	679,077	729,249	714,149
Pelagic fishes	58,775	70,842	127,596	136,463	175,371	296,639	456,220	201,415	323,610	257,577
Squids, cuttlefishes, Octopus	27,926	56,075	49,759	46,222	50,725	56,386	76,451	68,703	64,351	57,216
Crustaceans	31,892	48,412	85,809	69,293	73,910	74,114	105,822	102,182	87,961	92,562
Sharks and rays	5,545	9,337	5,321	3,306	4,775	4,432	5,411	3,946	4,127	5,363
Tunas and billfishes	3,448	5,722	9,567	8,874	12,793	13,180	19,568	11,195	20,301	19,860
Others	-	-	-	-	127	3,448	13,430	31	164	99
Total	481,270	784,541	944,753	728,465	914,303	1,093,699	1,416,544	1,066,549	1,229,763	1,146,826

Species groups	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Demersal fishes	733,458	747,424	681,064	635,445	643,515	740,527	893,374	816,404	802,170	811,487
Pelagic fishes	307,374	267,679	336,313	381,388	398,658	366,105	367,749	359,949	417,305	379,575
Squids, cuttlefishes, Octopus	56,218	77,365	83,044	80,114	64,936	78,733	77,902	71,641	112,136	110,389
Crustaceans	100,16	144,70	110,50	86,617	74,651	84,925	90,373	70,738	128,38	125,72

	2	0	5						1	0
Sharks and rays	5,613	4,922	4,611	4,878	5,452	7,252	8,333	7,054	7,311	6,219
Tunas and billfishes	29,041	45,677	88,556	77,021	88,629	96,401	98,898	151,963	122,801	146,014
Others	-	-	5,143	118	-	-	3	-	-	-
Total	1,066,549	1,287,767	1,309,236	1,265,581	1,275,841	1,373,943	1,536,632	1,477,749	1,590,104	1,579,404

Appendix Table 1 (Continue)

Species groups	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demersal fishes	782,385	655,726	756,758	718,478	680,198	582,656	545,323	494,126	532,183	500,384
Pelagic fishes	322,179	405,750	378,446	425,316	472,186	430,480	409,580	397,788	389,629	397,047
Squids, cuttlefishes, Octopus	112,388	89,521	92,400	87,869	83,337	72,754	72,094	90,690	72,531	70,929
Crustaceans	136,757	126,215	131,691	132,638	133,584	128,259	120,802	104,043	94,202	100,563
Sharks and rays	5,626	3,849	4,323	4,703	5,082	3,102	2,702	3,186	4,370	4,322
Tunas and billfishes	33,938	33,172	36,345	35,943	35,540	26,594	24,313	22,890	18,942	14,433

Others	1,325	1	9,857	13,263	16,668	17,956	22,425	-	84,554	138,855
Total	1,394,598	1,314,234	1,409,820	1,418,208	1,426,595	1,261,801	1,197,239	1,112,723	1,196,411	1,226,533

Species groups	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Demersal fishes	422,713	406,863	456,141	433,929	407,296	376,135	380,032	443,334	457,733	392,580
Pelagic fishes	385,916	364,576	376,057	387,359	334,330	365,409	361,826	365,323	369,195	356,413
Squids, cuttlefishes, Octopus	99,890	90,576	88,751	75,699	72,362	89,708	78,795	92,202	75,117	71,181
Crustaceans	56,798	59,811	54,095	54,450	46,797	70,383	57,062	73,845	96,990	74,550
Sharks and rays	2,637	3,062	3,439	2,946	2,387	3,048	3,471	1,921	1,895	1,720
Tunas and billfishes	21,892	28,134	33,336	35,317	37,736	34,609	38,523	40,574	36,935	33,326
Others	4,737	1,897	2,423	7,708	5,701	10,927	4,696	9,516	2,193	32,566
Total	994,583	954,919	1,014,242	997,408	906,609	950,219	924,405	1,026,716	1,040,058	962,335

Appendix Table 1 (Continue)

Species groups	2021	2022	2023
Demersal fishes	367,707	376,134	428,562
Pelagic fishes	335,409	356,826	386,623
Squids, cuttlefishes, Octopus	71,161	82,014	69,073
Crustaceans	81,146	87,004	84,521
Sharks and rays	1,362	909	845
Tunas and billfishes	42,338	43,775	47,769
Others	4,812	5,299	5,135
Total	903,935	951,961	1,022,529

Appendix Table 2 Annual catch from inland fisheries in coastal provinces along the Gulf of Thailand between 2009 and 2023 (unit: metric tonne)

Species groups	2009	2010	2011	2012	2013	2014	2015	2016
Freshwater fishes	10,776.19	10,939.93	11,902.57	14,359.64	13,999.56	11,343.42	11,526.31	12,230.13
Freshwater crustaceans	384.7	357.03	396.12	400.35	540.62	478.25	488.63	472.14
Others	3.31	6.02	53.79	50.24	115.63	70.39	67.49	75.8
Total	**11,164.2**	**11,303**	**12,352.5**	**14,810.2**	**14,655.8**	**11,892.1**	**12,082.43**	**12,778.07**

Species groups	2017	2018	2019	2020	2021	2022	2023

Freshwater fishes	11,845.69	7,933.4	8,276.66	9,384.63	6,691.87	6,923.99	7,921.78
Freshwater crustaceans	562.16	864.5	787.19	688.33	291.86	563.16	396.97
Others	230.36	89.62	46.27	24.53	27.1	21.41	43.94
Total	**12,638.21**	**8,887.52**	**9,110.12**	**10,097.49**	**7,010.83**	**7,508.56**	**8,362.69**

Appendix Table 3 Aquaculture production in coastal provinces along the Gulf of Thailand between 2016 and 2023 (unit: metric tonne)

Province	2016	2017	2018	2019	2020	2021	2022	2023
Trat	28,931.11	26,461.29	28,342.28	26,720.14	27,516.93	31,283.31	27,135.72	22,925.70
Chanthaburi	42,310.32	42,424.57	34,943.62	38,689.36	33,435.86	29,801.47	30,759.71	30,455.96
Rayong	14,443.74	14,300.22	12,856.04	11,792.45	12,641.12	10,962.46	10,319.53	10,121.49
Chon Buri	29,597.86	25,785.40	16,573.89	15,094.28	11,567.86	17,208.85	15,000.00	16,795.10
Chachoengsao	55,795.29	54,772.12	65,576.85	70,438.33	67,622.44	67,853.81	74,772.93	80,746.78
Samut Prakan	81,315.41	25,382.81	25,986.65	34,522.93	64,320.25	46,823.28	56,307.26	55,936.93
Bangkok	7,838.90	6,196.47	8,731.55	5,272.65	7,936.10	7,988.82	6,620.22	7,093.93
Samut Sakhon	20,001.05	22,757.42	43,485.22	34,626.36	31,799.90	35,947.96	34,548.57	37,275.72
Samut Songkhram	29,105.12	27,923.77	23,413.62	31,831.39	35,798.62	25,672.56	31,427.70	43,395.14
Phetchaburi	17,390.54	15,753.14	21,484.74	20,550.85	17,960.56	20,494.00	19,162.24	18,787.32
Prachuap Khiri Khan	18,687.30	21,238.59	25,553.15	28,402.94	29,137.99	27,672.66	23,295.58	24,001.46
Chumphon	23,026.87	29,528.97	18,095.27	19,773.20	47,156.70	36,855.61	34,550.27	20,945.81
Surat Thani	74,786.76	59,598.66	55,332.87	63,294.13	55,010.56	58,396.91	56,747.88	69,262.64
Nakhon Si	25,497.15	28,114.66	28,949.84	39,190.69	39,232.84	38,669.65	31,334.30	31,290.64

Thammarat								
Songkhla	28,217.60	29,194.28	31,334.42	31,005.32	25,470.58	23,394.74	21,974.70	21,451.70
Pattani	8,771.92	9,919.23	6,504.52	5,443.18	5,420.88	5,209.69	4,170.00	4,687.77
Narathiwat	1,409.65	1,477.90	1,509.59	1,437.94	1,044.99	986.34	1,123.38	1,272.55
Total	**507,126.59**	**440,829.50**	**448,674.12**	**478,086.14**	**513,074.18**	**485,222.12**	**479,249.99**	**496,446.64**

Appendix Table 4 Number of fishing license by types of fishing gear issued to commercial fishing vessels in the coastal provinces along the Gulf of Thailand between 2016 and 2024

Type of fishing gear	2016	2017	2018	2019	2020	2021	2022	2023	2024
Trawls	3,087	3,043	2,975	2,965	2,925	2,745	2,592	2,540	2,351
Surround nets	956	852	782	767	725	713	653	638	587
Dredges	102	101	371	368	291	297	339	338	243
Lift nets	40	36	41	63	67	64	65	62	59
Falling gears	1,767	1,747	1,787	1,734	1,827	1,804	1,687	1,672	1,572
Gillnets/Entangling nets	810	802	888	857	934	916	812	816	757
Traps	794	776	903	887	1,511	1,509	1,403	1,418	1,275
Hook and lines	80	79	7,332	7,267	6,577	7,398	6,833	6,76	6,129
Miscellaneous gear	1,460	1,443	1,430	1,439	1,395	1,391	1,331	1,327	1,223
Total	**9,096**	**8,879**	**16,509**	**16,347**	**16,252**	**16,837**	**15,715**	**15,578**	**14,196**

Appendix Table 5 Number of fishing gear units by types of fishing gear and coastal provinces along the Gulf of Thailand in 2024

Province	Number of fishing gear unit				
	Trawls	Purse seines	Hook & lines	Others	Total
Trat	82	29	414	438	963
Chanthaburi	19	2	94	111	226
Rayong	8	119	452	641	1,220
Chon Buri	144	28	379	307	858
Chachoengsao	3	0	9	20	32
Samut Prakan	210	11	92	86	399
Bangkok	0	0	1	1	2
Samut Sakhon	168	51	317	228	764
Samut Songkhram	379	0	404	77	860

Phetchaburi	74	1	456	492	1,023
Prachuap Khiri Khan	85	85	581	501	1,252
Chumphon	153	82	723	679	1,637
Surat Thani	103	10	339	313	765
Nakhon Si Thammarat	572	7	722	192	1,493
Songkhla	195	16	339	255	805
Pattani	147	146	766	763	1,822
Narathiwat	9	0	41	25	75
Total	**2,351**	**587**	**6,129**	**5,129**	**14,196**

Appendix Table 6 Catch per unit effort (kg/hr) of DOF research vessels using otter board trawl in the Gulf of Thailand between 1961 and 2024

Year	CPUE	Year	CPUE	Year	CPUE
1961	297.80	1980	63.31	2008	25.33
1963	256.00	1981	51.03	2009	17.78
1964	225.60	1982	52.95	2010	18.56
1965	179.20	1983	51.08	2011	25.02
1966	172.94	1984	62.10	2012	18.23
1967	151.03	1985	57.82	2013	14.69
1968	139.04	1986	51.15	2014	21.94
1969	134.86	1987	40.59	2015	22.59
1970	127.90	1988	31.62	2016	12.61
1971	87.07	1989	22.71	2017	11.00
1972	82.90	1990	25.82	2018	11.73
1973	68.18	1992	37.12	2019	12.61
1974	75.75	1994	21.50	2020	13.52
1975	61.48	2003	22.37	2021	19.51
1976	75.13	2004	24.94	2022	19.79
1977	62.11	2005	24.20	2023	21.52
1978	68.52	2006	24.68	2024	16.62
1979	67.81	2007	19.78		

Remark: The cod-end mesh size used between 1961 and 2015 was 2.5 cm, while the cod-end mesh size of 4.0 cm has been used since 2016.

Appendix Table 7 Biomass assessment of some selected species in the Gulf of Thailand in 2023

Species Group	Scientific name	Common name	Biomass in 2023	Biomass at MSY	B/B_{MSY}
Demersal species	*Nemipterus hexodon*	Ornate threadfin bream	2,336.79	2,155.86	1.08
	Saurida elongata	Slender lizardfish	4,506.11	7,382.67	0.61
	Saurida undosquamis	Brushtooth lizardfish	6,107.84	29,379.74	0.21
	Priacanthus tayenus	Purple-spotted bigeye	7,432.31	6,246.14	1.19

	Penaeus merguiensis	Banana prawn	3,423.46	2,943.20	1.16
	Penaeus monodon	Giant tiger prawn	146.98	117.33	1.25
	Metapenaeus affinis	Jinga shrimp	1,166.91	922.44	1.27
	Metapenaeus ensis	Greasyback shrimp	622.38	450.61	1.38
	Portunus pelagicus	Blue swimming crab	14,396.24	10,437.71	1.38
	Uroteuthis duvaucelii	Indian squid	4,901.00	5,467.00	0.90
	Uroteuthis chinensis	Mitre squid	7,916.26	5,734.46	1.38
	Sepia aculeata	Needle cuttlefish	1,574.53	1,574.53	1.00
Pelagic fish	*Rastrelliger brachysoma*	Short mackerel	9,131.67	7,542.51	1.21
	Rastrelliger kanagurta	Indian mackerel	18,174.25	15,112.42	1.20
	Sardinella gibbosa	Goldstripe sardine	62,781.45	100,703.42	0.62
	Selaroides leptolepis	Yellowstripe scad	2,707.28	5,976.92	0.45
Anchovy	*Encrasicholina heteroloba*	Shorthead anchovy	17,470.37	12,067.86	1.45

Appendix Table 8 Catch by types of fishing gear (tonne) in the Gulf of Thailand between 2016 and 2024

Year	Bottom-impacting fishing gear					Other gear	Total	Percentage of catch	
	Pair trawl	Otter board trawl	Beam trawl	Clam dredge	Sub-total			Bottom-impacting fishing gear	Other gear
2016	243,274	162,728	16,673	18,767	441,442	508,777	950,219	46.46	53.54
2017	267,583	158,492	15,856	16,913	458,844	465,560	924,404	49.64	50.36
2018	289,115	172,341	15,456	19,186	496,098	530,618	1,026,716	48.32	51.68
2019	286,943	169,850	14,995	25,005	496,793	543,265	1,040,058	47.77	52.23
2020	272,265	135,532	12,657	23,743	444,197	518,140	962,337	46.16	53.84
2021	265,297	123,786	11,995	8,671	409,749	494,186	903,935	45.33	54.67
2022	239,430	122,074	12,258	6,906	380,668	571,258	951,926	39.99	60.01
2023	255,593	119,361	12,775	9,433	397,162	625,367	1,022,529	38.84	61.16
2024	243,775	115,856	13,901	7,147	380,679	586,276	966,955	39.37	60.63

Appendix Table 9 Species/species group and trophic level used to calculate Marine Trophic Index (MTI) in the Gulf of Thailand

No.	Species/group	Trophic level
1	Indian mackerel	3.1378
2	Short mackerel	3.1379
3	*Scomberomorus* spp.	3.9766
4	Adult caranx	3.5848
5	Juvenile caranx	3.0000
6	Pomfrets	3.5238
7	Adult anchovies	2.8997
8	Juvenile anchovies	2.8997
9	False trevally	3.6511
10	Coastal tunas	4.1624
11	Other small pelagic	2.8997
12	Large piscivores	4.2391
13	Sciaenidae	3.4574
14	Adult lizardfish	3.9547
15	Juvenile lizardfish	3.0000
16	Lutjanidae	3.9061
17	Plectorhynchidae	3.1995
18	*Priacanthus* spp.	3.3459
19	Sillago	3.2726
20	Adult Nemipterus	3.0759
21	Juvenile Nemipterus	3.0000
22	Ariidae	3.2515
23	Rays	3.1353
24	Sharks	4.5111
25	Small demersal fish	3.1787
26	Ponyfishes	2.6695
27	Medium demersal piscivore	3.9635
28	Medium demersal benthivore	3.2357
29	Trash fish	2.5574
30	Squids	3.2671
31	Cuttlefishes	3.2710
32	Octopods	3.2693
33	Metapenaeids	2.3454
34	Penaeids	2.3458
35	Sergestid shrimp	2.3456
36	Other shrimps	2.3456
37	Blue swimming crab	2.6159
38	Other crustaceans	2.6159
39	Shellfish	2.1994

Appendix A Maximum Sustainable Yield (MSY) and fishing effort assessment using Fox surplus production model

Fox surplus production model is used to calculate MSY in Thai waters. The model requires statistical data and information on catch, fishing effort, and catch per unit effort (CPUE). The catch data are collected from the main fishing gears used to catch each species group as shown in Table A.1.

Table A.1 Main fishing gears of each group of species in the Gulf of Thailand. The catches from the main fishing gears are used for MSY assessment for each group of species.

Species group	Main fishing gear
Demersal species	- Pair trawl - Otter board trawl - Beam trawl - Traps (fish trap, crab trap, squid trap, octopus trap) - Bottom gillnet (crab gillnet, shrimp trammel net, etc.) - Squid falling net - Krill push net - Clam dredge - Longline
Pelagic fish	- Purse seine - Pelagic gillnet (mackerel gillnet, sardine gillnet, etc.) - Pomfret lift net
Anchovy	- Anchovy purse seine - Anchovy falling net - Anchovy lift net

Since the catches are obtained from different types of fishing gear, a standard fishing effort is required for each group of species to calculate the MSY. The standard fishing gear for demersal species is research vessel, for pelagic fish is the purse seine, and for anchovy is the anchovy purse seine. The CPUE of the standard fishing gear is then used to calculate the standard fishing effort as follows.

$$E_j = Catch_j/CPUE_j$$

where E_j is fishing effort of $group_j$, $catch_j$ is summation of catch of $group_j$, and $CPUE_j$ is the CPUE of standard gear of $group_j$.

The relationship between CPUE and fishing effort was assumed as,

$$\ln CPUE_i = c + dE_i$$

where $CPUE_i$ is catch per unit effort in year i, and E_i is fishing effort in year i. c and d are regression coefficients.

Since yield can be calculated as $CPUE_i \times E_i$, MSY and fishing effort at MSY (E_{MSY}) can be calculated, once *c* and *d* are estimated from CPUE and effort data as the equations below.

$$MSY = -\frac{1}{d}\, e^{c-1}$$

$$E_{MSY} = -\frac{1}{d}$$

Appendix B Key principles and management measures under the Royal Ordinance on Fisheries B.E. 2558 (2015) and its amendments

Section 5 defines "coastal sea" as the sea within the Kingdom extending up to three nautical miles from the baselines. Considering exigencies based on purposes related to aquatic resource management, a Ministerial Regulation may be issued to determine the expanse of coastal seas in any area to cover a distance starting from the baseline shorter or further than three nautical miles as appropriate. Any such adjustment shall not result in a distance off the baseline of less than one point five nautical miles nor of further than twelve nautical miles.

According to the provisions of Section 5, the DOF has defined coastal seas as approximately 1.5 – 10.0 nautical miles (Figure B.1), in which only artisanal fishing is permitted, following **Section 38** stipulating that a commercial fishing licensee must not engage in a fishing operation in coastal seas.

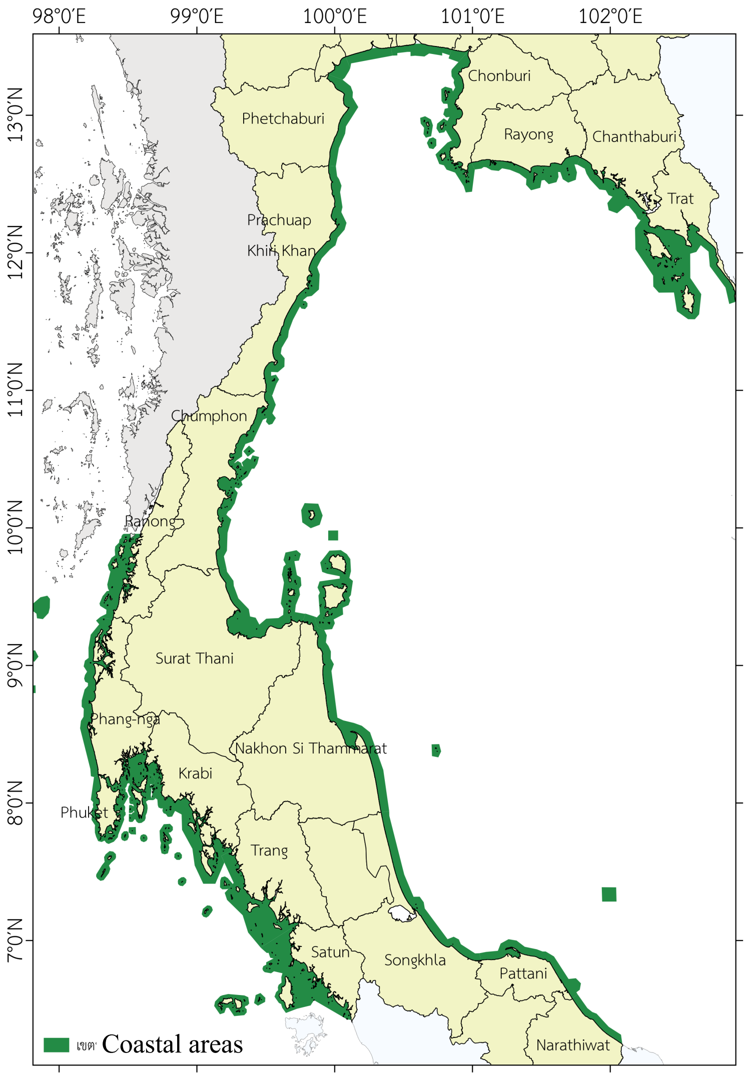

Figure B.1 Coastal seas in Thai waters ประกาศตาม based on the Royal Ordinance on Fisheries B.E. 2558 (2025)

Section 23 stipulates that the Fisheries Department shall take actions to develop and submit a Fisheries Management Plan to the National Fisheries Committee for deliberation. This plan shall subsequently be submitted to the cabinet for approval and implementation by agencies concerned.

Section 24 The Fisheries Management Plan under Section 23 must cover at least 8 guidelines. The important guidelines related to marine fisheries management include:

1) Guideline for issuing fishing licenses aligned with fishing capacity and maximum sustainable yield, using reference points as a basis for consideration,
2) Guideline for reducing number of fishing vessels engaged in commercial fishing operations, and
3) Guideline for preventing the catching of aquatic animals of premature sizes.

Under Section 23 and 24, the Department of Fisheries has developed the current Fisheries Management Policy and Plan for 2023 – 2027. The plan consists of five policies: marine fishery, inland fishery, overseas fishery, aquaculture, and fishery-related industry. For marine fishery, the policy states “Fisheries resources in Thai waters and aquatic habitats have become more abundant, allowing fishers to increase their catch. Marine fishing in Thai waters is free from illegal fishing practices, and labor in the fisheries sector is legal and sufficiently available.”

The Fisheries Management Policy and Plan outline four strategies. Each strategy contains several approaches, and each approach comprises multiple activities. All policy activities are embedded in each strategy and approach. The strategies and activities related to marine fisheries are presented as follows.

<u>Strategy 1: Conserve and Restore Ecosystem, and Maintain Ecosystem Balance</u>

Approach 1: Enhance the abundance of fisheries resources and aquatic habitats (16 activities)

Marine fishery-related activities include:

- Implement mesh size regulations, fishing technique regulations, or gear specifications to reduce the catch of juvenile economic species
- Establish marine habitats (e.g., artificial reefs)
- Ecosystem Approach to Fisheries Management (EAFM) for coastal communities
- Allocate fishing effort and issue fishing licenses do not exceed the Maximum Sustainable Yield (MSY) in deep-sea waters
- Establish conservation areas in accordance with national and international laws

Approach 2: Increase productivity of economically important aquatic species (8 activities)

Approach 3: Maintain the populations of rare and threatened aquatic species and preserve biodiversity (4 activities)

<u>Strategy 2: Sustainable Fisheries Resource Management and Utilization</u>

Approach 1: Manage fisheries resources utilization based on reference points (8 activities)

Marine fishery-related activities include:

- Monitor resource utilization based on MSY assessments and ensure annual catch does not exceed MSY
- Allocate fishing days and monitor to ensure compliance
- Decommission excess fishing vessels to reduce overcapacity

- Enforce fishing gear standards
- Implement spatial management for specific aquatic species
- Combine fishing licenses

Approach 2: Develop and improve the MCS (Monitoring, Control, and Surveillance) system, and revise the legal framework to be suitable to current situation and to prevent IUU fishing (4 activities)

Marine fishery-related activities include:

- Monitor and regulate fishing vessel operations in accordance with the law
- Raise awareness and support local fishing communities to prevent IUU fishing

Approach 3: Establish international and regional cooperation networks to combat illegal fishing (5 activities)

Approach 4: Encourage community participation in monitoring, control, and surveillance, and assessment of aquatic resources (4 activities)

Approach 5: Eliminate illegal fishing gear and regulate fisheries in Songkhla Lake (3 activities)

<u>Strategy 3: Enhance Competitiveness and Capacity of Fishers, Farmers, and Entrepreneurs</u>

Approach 1: Develop technology and build capacity for fishers and entrepreneurs (8 activities)

Marine fishery-related activities include:

- Develop alternative energy and technology for small-scale fishing vessels

Approach 2: Build capacity of aquaculture farmers and entrepreneurs to meet fisheries standards (6 activities)

Approach 3: Promote group formation and cooperation with domestic and international agencies (2 activities)

Approach 4: Promote and transfer sustainable and environmentally friendly aquaculture technologies (6 activities)

Approach 5: Upgrade fishery products to meet quality standards with full traceability across the supply chain (8 activities)

Marine fishery-related activities include:

- Improve fisheries under the Fishery Improvement Project (FIP) to meet international standards

<u>Strategy 4: Fisheries Technology and Innovation Development</u>

Approach 1: Research and develop freshwater fisheries technology (4 activities)

Approach 2: Research and develop coastal fisheries technology (2 activities)

Marine fishery-related activities include:

- Survey deep-sea resources and disseminate information on potential fishing areas
- Demonstrate deep-sea fishing gear and operations using research vessels

Approach 3: Research and develop technology for fisheries beyond national waters (2 activities)

Approach 4: Research and develop aquaculture technology (5 activities)

Approach 5: Research and develop technology for fishery-related industries (1 activity)

Section 36 Any person wishing to engage in commercial fishing must obtain a commercial fishing license issued by the Department of Fisheries.

The issuance of a license pursuant to paragraph one shall be executed specifically for a particular fishing vessel. The number and type of fishing gears authorized for the purposes of fishing operation, areas in which fishing operations are to be undertaken, the maximum allowable catch of aquatic animals allowed for fishing operations or the period during which fishing operations are allowed shall also be specified on the license in alignment with the fishing capacity and the MSY of aquatic animals for the purposes of sustainable fisheries stipulated in the Fisheries Management Plan.

According to the regulations in Section 36, the Department of Fisheries has specified the size and number of fishing gear that can be licensed for all types of gear, such as otter board trawl with a ground rope length not exceeding 60 meters, anchovy purse seine with a head rope length not exceeding 1,000 meters, and fish trap not exceeding 300 traps, etc.

Section 43 No commercial fishing licensee shall engage in a fishing operation different from that specified in the license.

According to the requirements in Section 43, the Department of Fisheries has established the conditions for the use of fishing gear, referred to as fishing gear standards, which are specified in each type of fishing license. These include details such as the length and mesh size of trawl cover nets, the length of beams for beam trawls, and the specific characteristics of clam dredges.

Section 57 No person shall be permitted to catch or bring onto a fishing vessel juvenile aquatic animals of the size and quantity specified by the Minister.

The size or quantity limits for juvenile aquatic animals prohibited from being caught or brought onto a vessel may vary depending on the species of aquatic animal or may apply only to a specific area.

In implementing this section, the Department of Fisheries has prepared information for the announcement of Section, including blue swimming crab and short mackerel. However, such announcement must first go through public hearing involving all stakeholders.

Section 67 No person shall use or have in possession for the purpose of using any of the following fishing gears:

(1) a set bag net or any other tool exhibiting a similar character and requiring a similar method,

(2) a collapsible trap with more than two entrances or any other tool exhibiting a similar character and requiring a similar method,

(3) a trawl net or any other type of fishing gear with mesh sizes smaller than those prescribed by the Minister,

(4) a push net attached to a motor vessel except for krill push net, and

(5) other fishing gear as announced by the Minister.

Section 69 No person shall use any type of surrounding net with the mesh size smaller than two point five centimeters to engage in a fishing operation at night. However, fishing operation at night outside the 12 nautical miles of the coastal waters can be permitted, subject to research supporting the fact that such fishing does not disrupt the ecological balance.

Section 70 No person shall fish in the area and during the spawning season for aquatic animals, or larval rearing, or any other period necessary for the protection of aquatic animals as announced by the Director-General.

Under this section, the Department of Fisheries has issued three Department of Fisheries Notifications prohibiting fishing during the spawning and larval rearing seasons in the Gulf of Thailand: 1) certain areas of Prachuap Khiri Khan, Chumphon and Surat Thani provinces; 2) the area between Mueang and Hua Hin districts, Prachuap Khiri Khan province; and 3) the inner Gulf of Thailand (Figure B.2).

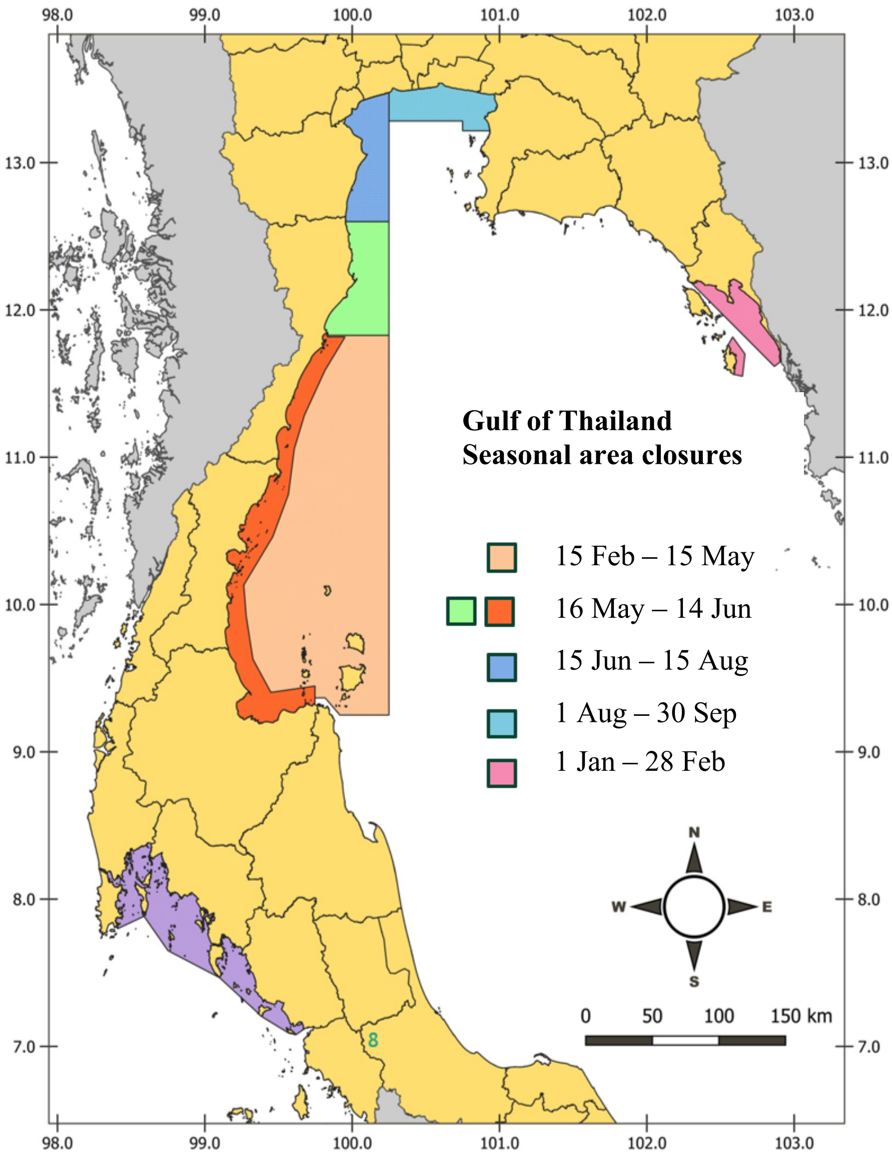

Figure B.2 Seasonal area closures in the Gulf of Thailand

Section 71 The Minister or the provincial fisheries committee shall have the power to issue notifications regarding the following:

(1) fishing gears, fishing methods, fishing areas, the size of fishing vessels used in fishing operations and other conditions that are prohibited from fishing operations,

(2) requirements to be complied with in relation to bycatch,

(3) an area necessitating the use of a fishing gear that requires pegging down,

pitching, tying, stretching, pulling, sinking or any other method to keep any such tool fixed during a fishing operation.

Under this section, the Department of Fisheries has issued a Department of Fisheries Notifications prescribing fishing gear, fishing methods, fishing areas, and conditions prohibiting fishing in certain fishing grounds in Trat province B.E. 2565 (2022) (Figure 3). Moreover, the Surat Thani Provincial Fisheries Committee has issued notification prohibiting the use of certain types of fishing gear in coastal waters around Koh Set, Phum Riang Subdistrict, Chaiya District, Surat Thani Province, B.E. 2565 (2022). These two areas are recognized as fisheries refugia established to protect critical habitats for short mackerel and blue swimming crab.

In addition to the notifications issued under the Royal Ordinance on Fisheries 2025, there are also other notifications issued under ministerial regulations, including the Department of Fisheries Notification on the types of fishing gear eligible for transfer of fishing rights, B.E. 2558 (2025). Following the National Fisheries Committee's determination of the Total Allowable Catch (TAC), based on the MSY, which is used as a reference point, the Department of Fisheries allocates the TAC to each fishing vessel. In cases where fishing vessels using high-efficiency fishing gear are not fishing or have surplus allocated catch, these can be transferred to other fishing vessels.

Annex IV: Governance

Annex 1: GDP, GDP growth rate, GDP per capita, Inflation rate, Poverty headcount, and employment rate of Thailand (2000-2024)

Year	GDP (current million US$)	GDP growth (annual %)	Inflation, consumer prices (annual %)	GDP per capita (current US$)	Unemployment rate, total (% of total labor force) (national estimate)	Poverty headcount ratio at $8.30 a day (2021 PPP) (% of population)
2000	126.4	4.5	1.3	2,006.0	2.4	61.2
2001	120.3	3.4	2.2	1,889.9	2.6	***
2002	134.3	6.1	1.6	2,089.8	***	53.3
2003	152.3	7.2	3.3	2,347.5	1.5	***
2004	172.9	6.3	3.2	2,641.6	1.5	46.7
2005	189.3	4.2	4.5	2,867.7	1.4	***
2006	221.8	5.0	4.6	3,331.3	1.2	39.5
2007	262.9	5.4	2.2	3,918.5	1.2	37.4
2008	291.4	1.7	5.5	4,309.1	1.2	35.2
2009	281.7	-0.7	-0.9	4,135.4	1.5	32.2
2010	341.1	7.5	3.3	4,973.9	0.6	30.0
2011	370.8	0.8	3.8	5,373.6	0.7	25.5
2012	397.6	7.2	3.0	5,725.5	0.6	24.9
2013	420.3	2.7	2.2	6,018.1	0.2	21.8
2014	407.3	1.0	1.9	5,801.2	0.6	20.9
2015	401.3	3.1	-0.9	5,688.9	0.6	16.9
2016	413.4	3.4	0.2	5,833.6	0.7	17.9
2017	456.4	4.2	0.7	6,413.1	0.8	17.2
2018	506.8	4.2	1.1	7,099.8	0.8	17.8
2019	544.0	2.1	0.7	7,605.7	0.7	15.2
2020	500.5	-6.1	-0.8	6,985.6	1.1	15.1
2021	506.2	1.6	1.2	7,057.2	1.2	14.1
2022	495.6	2.6	-1.6	6,909.4	0.9	9.9
2023	515.9	2.0	8.5	7,195.1	0.7	9.9
2024	526.4	2.5	1.4	7,345.1	0.8	***

Source:
The world bank group. Databank: world development indicators. Retrieved November 5, 2025 from https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.PCAP.CD&country=THA#

*** = No data

The development of Thailand’s economy has varied across different periods, as detailed as follows:

• 2000–2006:
During the early 2000s, the Thai economy was in a recovery phase following the Asian financial crisis of 1997–1998, which had severely affected the financial system and productive sectors. However, under expansionary economic policies and strong export performance, the economy began to stabilize and expand. GDP increased from USD 126.4 billion in 2000 to USD 221.8 billion in 2006, representing an average annual growth rate of approximately 5.2%. Notably, growth reached 7.2% in 2003, driven largely by industrial exports. Inflation remained moderate, ranging between 1.3% and 4.6%.

• 2007–2012:
Between 2007 and 2012, the Thai economy continued to grow, with GDP rising from USD 262.9 billion in 2007 to USD 397.6 billion in 2012. The average annual growth rate was around 3.7%, supported by export expansion, investment by small and medium-sized enterprises (SMEs), and sustained growth in tourism. The economy was affected by the 2008–2009 global financial crisis, resulting in growth of only 1.7% in 2008 and a contraction of –0.7% in 2009. Nonetheless, Thailand recovered quickly, achieving a strong rebound of 7.5% in 2010 due to government stimulus measures and a resurgence in exports. Inflation during this period fluctuated between –0.9% and 5.5%, influenced mainly by global oil price volatility.

• 2013–2015:
In 2013, Thailand’s GDP reached approximately USD 420.3 billion, growing at 2.7% from the previous year, reflecting continued strength in the industrial and service sectors. However, economic momentum slowed thereafter, with GDP dropping to USD 401.3 billion in 2015, despite growth of 3.1%. This slowdown was linked to currency depreciation and heightened political uncertainty. Deflation emerged in 2015, with inflation dropping to –0.9%.

• 2016–2019:
The economy experienced modest but consistent growth, averaging around 3.5% per year. GDP increased from USD 413.4 billion in 2016 to USD 544 billion in 2019, supported by exports, private investment, and continued expansion in tourism. Inflation remained low and stable, ranging from 0.2% to 1.1%.

• 2020:
The COVID-19 pandemic led to a severe economic contraction of –6.1% in 2020, with GDP falling to around USD 500 billion. Economic recovery remained incomplete in the following year, as tourism and service sectors—key drivers of national growth—were heavily affected. Inflation stood at –0.8%.

• 2021–2024:
Although the economy began to recover from the impacts of COVID-19, the rebound was slow, and growth remained below pre-pandemic levels, ranging between 1.6% and 2.6%. Political uncertainty, rising energy prices, and slowing exports contributed to growth below potential. In 2024, GDP reached USD 526.4 billion. Inflation was moderately high at 8.5% in 2023 but declined to 1.4% in 2024.

GDP per capita has shown a generally upward trend, increasing from USD 2,006 in 2000 to USD 7,605 in 2019. However, income per capita declined to around USD 7,000 during 2020–2022 due to pandemic-related impacts before recovering to USD 7,345 in 2024. This reflects a relatively slow recovery in household income associated with reduced employment in tourism, services, and the informal sector.

During 2000–2002, the unemployment rate ranged between 2.4% and 2.6%. After 2004, overall unemployment remained low, between 1–2%, indicating labour market stability, although these figures may not fully capture realities due to the high number of informal workers.

Annex 2: Main economic activities of coastal provinces of the Gulf of Thailand.

Province	Main economic activities
Trat	Marine tourism (Koh Chang, Koh Kood), small-scale fisheries, and border trade
Chantha Buri	Fruit agriculture (durian, mangosteen), food processing, fisheries
Rayong	Petrochemical industry, Map Ta Phut industrial port, energy production
Chon Buri	Laem Chabang seaport, the automotive industry, and tourism (Pattaya)
Chachoengsao	Agro-processing industry, logistics, food factories
Bangkok	Services, finance, trade, transportation, Khlong Toei commercial port
Samut Prakarn	Shipbuilding, electronics manufacturing, logistics, and automotive components
Samut Sakhon	Processed seafood industry, marine fisheries, seafood export
Samut Songkharm	Coastal fisheries, agriculture, and seafood processing
Petchaburi	Coastal tourism (Cha Am), agro-processing, fisheries, and fruit products
Prachuap Khiri Khan	Tourism (Hua Hin), agriculture, and coastal fisheries
Chumpon	Marine fisheries, agriculture (coffee, oil palm), tourism, seafood processing
Surat Thani	Tourism (Koh Samui), passenger marine transport, fisheries, rubber production
Nakhon Si Thammarat	Agriculture (oil palm, fruits), fisheries, and border trade
Songkhla	Deep-sea port, higher education, border trade, food industry
Pattani	Small-scale fisheries, agriculture, and traditional food processing
Narathiwat	Fisheries, agriculture (rice, palm oil), and border commerce

Annex 3: GPP, GPP per capita and Poverty headcount of the 16 coastal provinces of the Gulf of Thailand in 2023 (Office of the National Economic Social and Development Council, 2025)

	GPP (Billion USD)	GPP per capita (USD)	Poverty headcount (% of population)
Whole Kingdom	515.94	7,366.25	3.41
Rayong	30.2	27,074.86	0.00%
Chon Buri	34.14	17,021.13	0.34%
Chachoengsao	12.95	14,080.60	0.44%
Samut Sakhon	11.8	10,748.73	2.16%
Samut Prakarn	21.77	9,203.85	0.42%
Chantha Buri	4.18	7,285.11	2.39%
Chumpon	3.32	6,618.37	1.30%
Surat Thani	6.33	5,407.49	3.67%
Samut Songkharm	0.84	4,803.57	3.67%
Trat	1.33	4,736.65	4.91
Petchburi	2.27	4,503.42	4.76%
Songkhla	7.23	4,246.82	1.94%
Nakhon Si Thammarat	5.59	3,661.05	8.18%
Prachuap Khiri Khan	3.09	3,090.84	9.49%
Pattani	1.56	2,395.66	23.36%
Narathiwat	1.36	1,839.23	19.12%

Annex 4: Approved Domestic and Foreign Direct Investment Values by the Board of Investment (BOI), 2015–2024

Year	Domestic Direct Investment (DDI)		Other Investment (Not specified)		Foreign Direct Investment (FDI)		Total Investment
	Million USD	%	Million USD	%	Million USD	%	Million USD
2015	7,965.68	33.75	1,240.91	5.26	14,397.49	61.00	23,604.08
2016	9,427.02	37.49	5,265.86	20.94	10,455.74	41.58	25,148.63
2017	7,492.47	42.30	3,786.19	21.38	6,433.92	36.32	17,712.58
2018	3,593.57	21.12	5,504.76	32.36	7,913.47	46.52	17,011.79
2019	3,763.75	26.11	1,567.58	10.88	9,080.95	63.01	14,412.28
2020	2,910.34	25.20	578.01	5.01	8,058.37	69.79	11,546.72
2021	5,676.86	35.49	1,549.11	9.68	8,770.92	54.83	15,996.89
2022	2,960.63	16.80	5,534.25	31.40	9,129.49	51.80	17,624.36
2023	4,382.10	20.33	1,109.89	5.15	16,063.48	74.52	21,555.46
2024	6,124.70	21.84	965.88	3.44	20,954.03	74.72	28,044.61

Sources: Thailand Board of investment (BOI). (2025). BOI Data: Investment Promotion Statistical Reports (from 2015 onwards). Retrieved September 3, 2025 from https://ipstat.boi.go.th/pubrpt/index.php

Annex 5: Provincial investment of the Gulf of Thailand in 2024 (1 USD = 35 Baht)

Province	**BOI (Board of Investment)**									
	No. of Project	Total Investment		Total DDI and FDI registered capital		DDI registered capital		FDI registere capital		
		USD mil.	%	USD mil.	%	USD mil.	%	USD mil.		
Rayong	364	5,340.25	35.90	704.46	25.30	28.14	3.99	676.31	96	
Chonburi	565	4,321.09	29.05	1247.37	44.80	129.80	10.41	1,117.57	89	
Samut Prakan	227	3,380.86	22.73	292.97	10.52	58.60	20.00	234.37	80	
Chachoengsao	109	1,035.27	6.96	349.06	12.54	22.51	6.45	326.54	93	
Samut Sakhon	125	393.48	2.65	71.06	2.55	41.34	58.18	29.71	41	
Phetchaburi	21	107.10	0.72	33.40	1.20	8.31	24.89	25.09	75	
Songkhla	35	107.07	0.72	56.29	2.02	39.49	70.15	16.80	29	
Nakhon Si Thammarat	9	59.28	0.40	0.17	0.01	0.17	100.00	-		
Chumphon	7	46.48	0.31	13.46	0.48	13.46	100.00	-		
Surat Thani	24	36.27	0.24	4.09	0.15	4.03	98.60	0.06	1.	
Prachuap Khiri Khan	7	23.91	0.16	0.00	0.00	-	-	-		
Trat	1	10.64	0.07	0.00	0.00	-	-	-		
Samut Songkhram	2	6.40	0.04	0.11	0.00	0.11	100.00	-		
Chanthaburi	5	5.55	0.04	3.77	0.14	2.89	76.52	0.89	23	
Narathiwat	2	1.93	0.01	8.03	0.29	8.03	100.00	-		
Pattani	1	0.62	0.00	0.00	0.00	-	-	-		
Total	1504	14,876.17	100.00	2784.23	100.00	356.89	12.82	2,427.34	87	

Sources:

1. Thailand Board of investment (BOI). (2025). BOI Data: Investment Promotion Statistical Reports (from 2015 onwards). Retrieved September 3, 2025 from https://ipstat.boi.go.th/pubrpt/index.php

2. Department of Business Development (DBD). (2025). Statistics data 2024. Retrieved September 3, 2025 from https://www.dbd.go.th/common-article/24

Annex 6: Government agencies with roles in the marine space

Ministry	Agency	Activities
Ministry of Natural Resources and Environment	Department of Marine and Coastal Resources (DMCR)	Conserving, rehabilitating, and managing Thailand’s marine and coastal resources. Its responsibilities include establishing marine and coastal protected areas, restoring ecosystems such as mangroves, seagrass, and coral reefs, promoting sustainable use of resources, and coordinating Marine Spatial Planning (MSP)
	Department of Pollution Control (PCD)	Preventing, controlling, and mitigating marine and coastal pollution in Thailand. Its mandate covers monitoring water quality, regulating land-based pollution sources, managing waste and hazardous materials, and coordinating oil spill responses.
	Department of National Parks, Wildlife and Plant Conservation (DNP)	Establishing and managing marine national parks in Thailand, protecting endangered marine species and coastal ecosystems. Its mandate covers law enforcement, ecological restoration, and the promotion of sustainable eco-tourism, ensuring that marine resources are conserved while supporting local livelihoods.
	Office of Natural Resources and Environmental Policy and Planning (ONEP)	Proposes policies and plans for the conservation and management of natural resources and the environment, and oversees environmental impact assessments and environmental consents.
	Department of Climate Change and Environment (DCCE)	**Recently created (announced in the Royal Gazette, Effective from 18 August 2023). central coordination agency of the country under the United Nations Framework Convention on Climate Change, and drive Thailand's climate change operations, including greenhouse gas reduction (Mitigation), adaptation (Adaptation), and enhancing management capabilities**
	Department of Mineral Resources (DMR)	The DMR is responsible for the conservation, restoration, and management of geological resources, fossils, environmental geology, and geological hazards. In relation to marine management, DMR contributes through coastal geology studies, monitoring shoreline changes, managing marine mineral resources, and assessing risks such as coastal erosion, tsunamis, and other geohazards. These

Ministry	Agency	Activities
		functions support sustainable coastal development and disaster risk reduction in Thailand.
Ministry of Agriculture and Cooperatives	Department of Fisheries	Carries out research and studies in all areas of fisheries. It also helps support and develop fisheries-related jobs to make sure the sector continues to grow in the future.
Ministry of Transportation	Marine Department	Oversees and develops water transport and shipping in Thailand, making sure it connects well with other forms of transport. Its work includes ship registration, safety checks, enforcing maritime laws, and preparing navigation maps to keep water transport safe and efficient
Royal Thai Navy	Royal Thai Navy	Maintaining maritime security and interests (in coordination with ONSC)
Ministry of Energy	Department of Mineral Fuels (DMF)	Offshore oil and gas
Ministry of Tourism and Sports	Department of Tourism (DOT)	Oversees marine and coastal sustainable tourism activities
Ministry of Interior	Department of Public Works and Town Planning (DPT)	Oversees town and country planning, public works, and building control. It supports local authorities in land use, rural development, and infrastructure, while ensuring policies align with sustainable growth. DPT also sets standards in architecture, engineering, and planning to promote safety, orderliness, and a healthy environment.
	Department of Provincial Administration (DOPA)	Plays a central role in coastal governance by defining provincial sea boundaries, which provide the legal basis for coastal and marine management. It coordinates with agencies such as the Marine Department, Department of Fisheries, and Department of Marine and Coastal Resources to align policies on resource use and conservation. DOPA also supports local administrative bodies in coastal development while ensuring law enforcement and public order.
Ministry of Social Development and Human Security	Department of Social Development and Welfare (DSDW),	Protect and enhance the way of life for ethnic communities residing along the shore
Office of the Prime Minister	Office of the National Security Council (ONSC)	Maintaining maritime security and interests

Ministry	Agency	Activities
	Thai-MECC	Carry out surveillance and investigation into any matter deemed a threat to Thailand's maritime interests and exercise tactical control over the Royal Thai Navy. As per the Maritime National Interests Protection Act (2019), Thai-MECC has the duty to plan, administer, coordinate, order, and support the operation of the state agencies involved in the maritime national interests.
	National Economic and Social Development Board (NESDB)	Oversees the implementation of the thirteenth national economic and social development plan (2023-2027), including the Natural Resources and Environmental Dimension of the National Development Context, which includes marine and coastal resources. It is also responsible for setting up the coordination mechanism between the NESDB, concerned agencies, and state enterprises regarding the planning and implementation of development programs and projects.

Annex 7: Institutions' roles (Policy committees) and relevance to the marine and coastal resources management

Institution	Relevance to marine and coastal resources management
National Policy and Plan Committee on Marine and Coastal Resource Management (NMCRC)	Oversees marine and coastal resource management policies. Supported by DMCR, it formulates policies, plans, and guidelines for sustainable use and conservation, including the designation of marine and coastal protected areas.
National Maritime Interests Protection Policy Committee (MIP)	Focuses on protecting Thailand’s maritime interests. Supported by the Office of NSC, it develops policies and strategies for maritime security and sustainable use. Six Sub-committees are established to support its tasks. These include: 1) Sub-committee on Advice & Knowledge management for the national maritime interest (SAKM), which contain 6 working groups (Stable aspects, Prosperity and Sustainable aspects, Legal aspects, Public relation aspect, Advocacy of the Thai Ocean Health Index Evaluation, and establishing a Thai Marine Think Tank); 2) Sub-committee on evaluating the national maritime security plan; 3) Sub-committee on coordination & monitoring of national maritime security plan; 4) Sub- committee on marine interests and security situation assessment; 5) Sub-committee on drafting maritime security index for the national maritime security plan; and 6) Sub- committee on Marine Use Zoning for MSP Thailand (Sub-com MSP).
National Environment Board (NEB)	Provides policy direction on environmental management. Supported by ONEP, it integrates MSP into broader environmental conservation policies and frameworks.
National Economic and Social Development Council (NESDC)	Coordinates Thailand’s economic and social development planning. Supports marine and coastal resources conservation by aligning it with national development plans such as the Thirteenth NESDP.
National Committee on Conservation and Utilization of Biodiversity (NCB)	Oversees biodiversity conservation policies. Ensures integration of MSP with goals for protecting marine and coastal biodiversity.
National Committee on Climate Change Policy (NCCC)	Develops climate change policies and strategies. Ensures MSP incorporates climate resilience and adaptation measures for marine and coastal areas.
National Fishery Policy Committee (NFPC)	Governs fisheries policy and management. Aligns fisheries management with the objectives to ensure sustainable use of marine resources.
National Park Committee (NPC)	Manages national parks and protected areas. Facilitates the inclusion of marine protected areas in the marine and coastal resources.

Institution	Relevance to marine and coastal resources management
Subcommittee on Management of Marine and Coastal Resources (under NMCRC)	Focuses on approving policy and management plans for marine and coastal resources, and the designation and management of marine and coastal protected areas. Eight subcommittees are created to support the NMCRC dealing with specific issues include: 1) mangrove and beach forest, 2) coastal erosion, 3) marine environment protection, 4) annual performance report, 5) stakeholders' participation in marine and coastal resources management, 6) managing marine and coastal resources (through designation of marine and coastal protected areas); 7) conservation of Dugong; 8) resolving coastal erosion problems around the areas of Mrigadayawan Palace.
Subcommittee on Marine Use Zoning in Thailand (under MIP)	Directly responsible for MSP implementation, including zoning and maritime boundary delineation to standardize marine management zones and ensure effective spatial planning.

Annex 8: Thailand's engagement with key global, regional, and bilateral partners

A. Global and Multilateral Engagement

1) DMCR–UNESCO Collaboration

DMCR collaborates with UNESCO to promote the conservation and sustainable management of marine and coastal ecosystems through science, education, and culture-based initiatives.

Thailand serves as a national focal point under UNESCO's Intergovernmental Oceanographic Commission (IOC), IOC/WESTPAC, and Man and the Biosphere (MAB) Program. Joint activities include management of the Ranong Biosphere Reserve, the Thailand Mangrove Alliance, and ocean literacy initiatives that support global frameworks such as the UN Decade of Ocean Science (2021-2030) and the Kunming–Montreal Global Biodiversity Framework (GBF).

2) DMCR-IOC Collaboration

DMCR acts as Thailand's national focal point for the IOC of UNESCO, which promotes international cooperation in ocean science, observation, and capacity development.
Thailand has been an active IOC member since 1960 and currently contributes to global initiatives such as the Global Ocean Observing System (GOOS) and tsunami early warning systems, enhancing regional preparedness and ocean data sharing.

As host of the IOC Sub-Commission for the Western Pacific (IOC/WESTPAC) Secretariat since 2005, DMCR leads regional efforts in marine scientific research, ocean observation, and capacity building among 22 member states. The collaboration also supports the Decade Coordination Office (DCO) for the UN Ocean Decade, promoting marine biodiversity research, blue carbon, MSP, and marine debris monitoring across the Western Pacific.

3) DMCR–UNEP Collaboration

DMCR works closely with the United Nations Environment Programme (UNEP) to strengthen marine and coastal resource management in line with international frameworks.

As host of the UNEP Asia and Pacific Regional Office in Bangkok, Thailand, actively engages in regional initiatives such as COBSEA and the United Nations Environment Assembly (UNEA). Cooperation focuses on marine litter reduction, ecosystem-based management, coral and mangrove protection, and progress toward SDG 14 and the 30x30 global marine target.

4) DMCR–BBNJ Collaboration

DMCR supports Thailand's commitments under the Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Agreement), adopted under UNCLOS. Thailand signed the Agreement on 17 April 2025 as the 113th signatory. DMCR's involvement includes coordination on Marine Genetic Resources (MGRs), Area-Based Management Tools (ABMTs), Environmental Impact Assessments (EIAs), and capacity building, enhancing Thailand's role in global ocean governance.

5) DMCR–IOI Collaboration

Through a Memorandum of Understanding (2022–2027), DMCR established the IOI Thailand Training Centre under the International Ocean Institute (IOI).

The centre provides regional training on UNCLOS implementation, marine biodiversity conservation, and fisheries governance, building professional capacity and strengthening Thailand's position in regional ocean education and policy leadership.

6) DMCR–IOSEA Marine Turtles MOU Collaboration

DMCR represents Thailand under the IOSEA Marine Turtles MOU of the Convention on Migratory Species (CMS) to conserve marine turtles and their habitats across the Indian Ocean and Southeast Asia. Through the Conservation and Management Plan (CMP), Thailand undertakes actions on nesting site protection, bycatch reduction, and community awareness, contributing to the long-term survival of endangered turtle species.

7) DMCR–Dugong MOU and Habitat Conservation Collaboration

Thailand is a signatory to the CMS Dugong MOU (2011) on the conservation of Dugong dugon and their seagrass habitats. DMCR coordinates national and regional actions to reduce dugong mortality, protect seagrass ecosystems, and build conservation capacity. As the National Focal Point, DMCR also participates in Meetings of Signatories (MOS) to enhance international collaboration on dugong protection and habitat restoration.

B. Regional Engagement

1) DMCR–COBSEA Collaboration

DMCR serves as Thailand's national focal point for the Coordinating Body on the Seas of East Asia (COBSEA) under UNEP. Thailand, host of the COBSEA Secretariat since 2015, contributes to the East Asian Seas Action Plan, the Regional Action Plan on Marine Litter (RAP MALI), and the South China Sea Strategic Action Programme (SCS SAP). Cooperation focuses on marine pollution control, ecosystem management, and blue economy development.

2) DMCR–ASEAN Working Group on Coastal and Marine Environment (AWGCME) Collaboration

As Chair (2019–2025) and National Focal Point, DMCR leads ASEAN efforts under the AWGCME to promote regional coordination on marine debris reduction, habitat conservation, and climate change adaptation. Key achievements include the Bangkok Declaration on Combating Marine Debris (2019) and the ASEAN Regional Action Plan for Combating Marine Debris (2021–2025).

3) DMCR–ASEAN Sub-Committee on Marine Science and Technology (SCMSAT) Collaboration

DMCR represents Thailand in SCMSAT under the ASEAN Committee on Science, Technology and Innovation (COSTI). The collaboration enhances regional research, innovation, and capacity building on marine biodiversity, ocean observation, and the ASEAN Blue Economy Roadmap.

4) DMCR–Ocean and Fisheries Working Group (OFWG) Collaboration

Under the APEC framework, DMCR supports the OFWG to promote sustainable ocean and fisheries management. Thailand contributes to regional initiatives on marine debris, IUU fishing prevention, and aquaculture sustainability, including the APEC Roadmaps on Marine Debris and IUU Fishing (2019).

5) DMCR–Blue Economy Working Group (WGBE) Collaboration

Within the Indian Ocean Rim Association (IORA), DMCR serves as Thailand's lead focal point for the WGBE, focusing on blue carbon, marine pollution, and ocean governance.

Collaboration includes training programs, ministerial dialogues, and research on renewable energy, marine biotechnology, and coastal tourism to strengthen sustainable blue economy development.

C. Bilateral and Innovation Partnerships

1) DMCR–The Ocean Cleanup B.V. Collaboration

DMCR signed a Memorandum of Understanding (2022) with The Ocean Cleanup B.V. (Netherlands) to enhance marine debris management and plastic pollution reduction in Thailand's rivers and coastal zones. The Interceptor Project, deployed in the Chao Phraya River, captures floating waste before it reaches the sea. This public–private partnership supports Thailand's National Marine Debris Management Plan and advances SDG 14 (Life Below Water) through innovation and technology-based solutions.

Annex 9: International Conventions and Global Policy Framework

Biodiversity-related Instruments

a) The Convention on Biological Diversity (CBD)

The CBD promotes the conservation of biological diversity, the sustainable use of its components, and the equitable sharing of benefits arising from genetic resources. It provides a global framework for ecosystem and species protection. Thailand, as a Party to the CBD, integrates its principles into national biodiversity strategies, action plans, and coastal ecosystem management frameworks.

b) The Kunming–Montreal Global Biodiversity Framework (GBF)

Adopted in 2022 under the CBD, the GBF sets global biodiversity targets to 2030, aiming to halt and reverse biodiversity loss. It introduces key goals such as protecting at least 30% of land and sea areas (“30x30 target”), restoring degraded ecosystems, and reducing harmful subsidies. Thailand aligns its biodiversity strategies and marine conservation plans with the GBF to strengthen marine protection and sustainable resource management.

c) The Ramsar Convention on Wetlands

The Ramsar Convention provides an international framework for the conservation and wise use of wetlands. Eleven coastal and marine wetlands in Thailand have been designated as **Wetlands of International Importance**, highlighting the country’s commitment to wetland and coastal ecosystem protection (Appendix xx)

d) The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES regulates international trade in wild animals and plants to prevent threats to species survival. Thailand implements its provisions through national legislation and enforcement to combat illegal wildlife trafficking and protect endangered marine species such as corals, seahorses, and marine turtles.

e) The World Heritage Convention (1972)

Administered by UNESCO in 1972, the Convention seeks to identify and preserve cultural and natural heritage sites of outstanding universal value. Thailand collaborates with UNESCO to protect and manage marine and coastal sites that represent biodiversity and cultural significance, such as mangrove and coral reef ecosystems.

f) The Convention on the Conservation of Migratory Species of Wild Animals (CMS, 1979)

The CMS, or Bonn Convention, promotes international cooperation for the conservation of migratory species and their habitats. Thailand, as a Party to CMS, contributes to protecting dugongs, marine turtles, dolphins, and seabirds, and participates in regional initiatives under the IOSEA Marine Turtle MOU and Dugong MOU.

Pollution-related Instruments

a) United Nations Convention on the Law of the Sea (UNCLOS, 1982)

UNCLOS establishes the comprehensive legal framework governing all ocean activities. It defines maritime zones (such as territorial sea, EEZ, and continental shelf), regulates navigation and resource use, and promotes marine environmental protection. Thailand implements its provisions through national legislation on fisheries, marine resource management, and maritime jurisdiction.

b) Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention, 1972)

This Convention aims to prevent marine pollution caused by waste dumping and establishes a global regulatory framework for controlling harmful discharges. Thailand enforces its principles through national laws governing waste management and pollution prevention.

c) International Convention for the Prevention of Pollution from Ships (MARPOL)

MARPOL serves as the main international treaty addressing ship-based pollution, including oil, chemicals, sewage, garbage, and air emissions. Thailand enforces MARPOL's six technical annexes to ensure safe shipping, protect coastal and marine environments, and support sustainable maritime transport.

d) Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989)

The Basel Convention regulates the transboundary movement and disposal of hazardous wastes to prevent illegal dumping and ensure environmentally sound management. Thailand implements strict controls on hazardous waste import, export, and disposal in line with sustainable development objectives.

e) Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC, 1990)

The OPRC establishes a global framework for preparedness and response to oil spills. Thailand maintains national and regional oil spill contingency plans, trained response units, and cooperative mechanisms to address pollution incidents.

f) Rotterdam Convention (1998)

This Convention promotes shared responsibility in the trade of hazardous chemicals and pesticides. Thailand implements the Prior Informed Consent (PIC) procedure to ensure transparency and safe management of chemical substances.

g) Stockholm Convention on Persistent Organic Pollutants (2001)

The Stockholm Convention aims to eliminate or restrict persistent organic pollutants (POPs— toxic chemicals that remain in the environment, accumulate in living organisms, and pose serious risks to humans and wildlife), harmful to human health and ecosystems. Thailand enforces regulations to phase out POPs (DDT, PCBs, and dioxins), manage contaminated sites, and promote safe waste disposal.

Climate Change-related Instruments

a) United Nations Framework Convention on Climate Change (UNFCCC, 1992)

The UNFCCC establishes a global framework for addressing climate change through mitigation, adaptation, and climate finance. Thailand integrates its commitments into national policies to reduce greenhouse gas emissions, enhance climate resilience, and protect vulnerable coastal ecosystems from climate-related impacts.

b) Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997)

The Kyoto Protocol strengthens the UNFCCC by setting emission reduction targets for developed countries and introducing mechanisms such as the **Clean Development Mechanism (CDM)**. Thailand participates in CDM projects supporting renewable energy and low-carbon development.

c) Paris Agreement to the United Nations Framework Convention on Climate Change (2015)

The Paris Agreement aims to limit global warming to well below 2°C and requires Parties to submit **Nationally Determined Contributions (NDCs)**. Thailand has pledged to reduce emissions, build climate resilience, and promote sustainable, low-carbon coastal development.

d) Montreal Protocol (1987)

Adopted under the Vienna Convention, the Montreal Protocol seeks to phase out ozone-depleting substances (ODS). Thailand implements ODS elimination measures and promotes alternatives that support both ozone and climate protection.

e) United Nations Convention to Combat Desertification (UNCCD, 1994)

The UNCCD focuses on combating land degradation and promoting sustainable land and water management. Thailand's national action plans address soil erosion, land rehabilitation, and drought mitigation, supporting broader climate resilience and sustainable development goals.

Annex 10: Regional Legal and Policy Frameworks and Forums

a) Partnerships in Environmental Management for the Seas of East Asia (PEMSEA)

The Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) is a regional partnership that promotes sustainable development and management of coastal and marine areas through the implementation of Integrated Coastal Management (ICM). It serves as a platform for governments and stakeholders to enhance marine governance, pollution control, and climate resilience. Thailand, as a participating country, collaborates with PEMSEA in advancing ICM initiatives, supporting marine spatial planning (MSP), and strengthening capacity building and policy harmonization in line with the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA).

b) Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI–CFF)

The CTI–CFF is a multilateral partnership among six countries—Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste—aimed at conserving the world's most biodiverse marine region, the Coral Triangle. Although Thailand is not a member country, it cooperates regionally through knowledge exchange, capacity building, and marine biodiversity research with CTI–CFF partners. These engagements strengthen Thailand's contribution to ecosystem-based management, coral reef conservation, and sustainable fisheries in the wider Indo-Pacific region.

c) Indian Ocean Tuna Commission (IOTC)

The Indian Ocean Tuna Commission (IOTC), established under the Food and Agriculture Organization (FAO), manages and conserves tuna and tuna-like species in the Indian Ocean and adjacent seas. Its objectives are to ensure the sustainable use of tuna resources, facilitate scientific data sharing, and coordinate fisheries management measures among member countries. Thailand, as a member of the IOTC, plays an influential role as one of the world's leading tuna processing and exporting nations. The government actively participates in scientific research, data reporting, and policy development to promote sustainable tuna harvesting, combat illegal, unreported, and unregulated (IUU) fishing, and strengthen regional food security.

d) ASEAN Agreement on the Conservation of Nature and Natural Resources (1985)

The ASEAN Agreement on the Conservation of Nature and Natural Resources (1985) is a pioneering regional legal instrument that promotes cooperation among ASEAN member states for the conservation and sustainable use of natural resources. It encompasses ecosystem and species protection, sustainable land and water management, and environmental pollution control. Although not all ASEAN member states have ratified the Agreement, Thailand upholds its principles through national policies on biodiversity conservation, sustainable development, and transboundary environmental cooperation, supporting ASEAN's broader framework for environmental governance and sustainability.

e) Regional Plan of Action to Promote Responsible Fishing Practices,

including Combating Illegal, Unreported, and Unregulated Fishing (RPOA–IUU)

The RPOA–IUU is a voluntary regional initiative established in 2007 by 11 countries in Southeast Asia and the Indian Ocean region to promote responsible fishing practices and strengthen the fight against IUU fishing. Participating countries include Thailand, Indonesia, Malaysia, and the Philippines, among others.
The plan's objectives are to:

- Enhance monitoring, control, and surveillance (MCS) of fishing activities;
- Improve information exchange and coordination among countries;
- Develop national and regional action plans to eliminate IUU fishing; and
- Promote sustainable fisheries management aligned with the FAO Code of Conduct for Responsible Fisheries.
  Thailand actively implements RPOA–IUU measures through improved vessel registration and tracking, legal reforms, and enhanced fisheries enforcement, contributing to the long-term sustainability of marine living resources.

Annex 11: Existing legal instruments and relevance to marine and coastal resources management

Legal Documents	Relevance to Marine Conservation
Marine and Coastal Resources Management Act B.E. 2558 (2015)	Empowers the Ministry of Natural Resources and Environment (MoNRE) to enforce the sustainable management of marine resources, coastal erosion prevention, and public participation. Establishes committees for policy coordination and the demarcation of marine protected areas, essential for the integrated and sustainable management of marine and coastal resources, thereby supporting marine and coastal resources conservation.
National Maritime Interests Protection Act B.E. 2562 (2019)	Defines Thailand's maritime interests and zones, empowering the Prime Minister to execute laws. Establishes the National Maritime Interests Protection Policy Committee (MIP) and Thai-MECC to coordinate maritime security and protect national maritime interests. Supports the alignment of biodiversity and ecosystem services with national maritime strategies and security.
Royal Ordinance on Fisheries B.E. 2558 (2015), amended 2560 (2017)	Provides amendments for modernized fisheries management, aligning with sustainable development principles to promote long-term sustainability and support marine conservation
Navigation in Thai Waters Act B.E. 2456 (1913)	Governs navigation in Thai waters, ensuring coordination of maritime transport and space use in ways that support marine conservation.
Thai Vessels Act B.E. 2481 (1938), amended B.E. 2561 (2018)	Regulates vessel registration and operations, ensuring the management of vessel activities within designated marine zones to support marine conservation.
Petroleum Act B.E. 2514 (1971)	Regulates petroleum exploration and extraction, ensuring a balance between economic use and environmental sustainability to protect biodiversity in marine areas.
Minerals Act B.E. 2560 (2017)	Governs mineral resource extraction, ensuring zoning and environmental protection measures that support marine conservation.
National Security Council Act B.E. 2559 (2016)	Provides a framework for addressing national security threats, including maritime security, while ensuring the integration of marine conservation with security measures.
Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992), amended 2561 (2018)	Prescribes measures for environmental conservation and pollution control, supporting biodiversity by promoting the sustainable use of marine and coastal environments.
National Park Act B.E. 2562 (2019)	Governs protected areas and biodiversity conservation, facilitating the integration of marine protected areas into broader conservation efforts and ecosystem sustainability, thereby supporting marine conservation.

Legal Documents	Relevance to Marine Conservation
Local Government Organization Act B.E. 2542 (1999)	Defines the roles of local governments in resource management, ensuring participatory and decentralized implementation that supports marine conservation.
National Tourism Policy Act B.E. 2546 (2003)	Regulates tourism development, ensuring a balance between tourism growth and marine conservation through environmental and spatial considerations.
National Economic and Social Development Board Act B.E. 2521 (1978)	Establishes strategic development frameworks that include both economic and environmental goals, supporting the integration of marine biodiversity into national development strategies
Regulation of the Prime Minister's Office on Conservation and Utilization of Biodiversity (2020)	Establishes the National Biodiversity Conservation Committee (NBC) to oversee national biodiversity policy, including approving management plans, regulatory measures, and frameworks on access to biological resources, benefit-sharing, biosafety, and technology transfer. Four subcommittees support its work: biodiversity law, integrated biodiversity management, academic and technical affairs, and international cooperation. These governance structures provide a critical foundation for advancing marine and coastal biodiversity conservation.
Draft National Biodiversity Act	Establishes the National Biodiversity Conservation Committee (NBCC) and defines biodiversity management across Thailand's territory, EEZ, high seas, and continental shelf in line with international law. It introduces a national biodiversity plan and allows for biodiversity protection zones, providing a strong legal framework to support marine and coastal conservation.
Draft Climate Change Act	Establishes the National Climate Change Policy Committee (NCCP) to lead climate policy and strategy. It mandates a National Climate Change Master Plan, updated every five years, along with action plans for greenhouse gas reduction and climate adaptation. These frameworks are essential for addressing climate risks to marine and coastal biodiversity, ensuring resilience and ecosystem-based adaptation
Protection and Promotion of Ethnic Groups' Way of Life Act B.E. 2568 (2025)	Supports the designation of areas to preserve ethnic cultures, promote sustainable natural resource use, and strengthen communities through traditional knowledge and customs. This approach is highly relevant to marine conservation, especially in coastal areas where ethnic communities rely on and steward marine ecosystems through customary practices.

Annex 12: Policy and plan relevant to marine and coastal resources in Thailand.

a) Thailand's 2030 Agenda and Sufficiency Economy Philosophy (SEP)

Thailand’s 2030 Agenda and Sufficiency Economy Philosophy (SEP) are foundational to the country’s sustainable development efforts. Every government agency is required to integrate SEP into its missions, plans, and policies, thereby promoting a sustainable development approach. The Agenda includes 5 goals and 18 targets directly related to biodiversity management, ranking them among the top 30 national priorities.

b) The 20-Year National Strategy (2017-2036)

The 20-Year National Strategy (2017-2036) is Thailand's first long-term national strategy, aimed at securing the country’s sustainability, prosperity, and security in line with SEP. Strategy 5: Eco-Friendly Development and Growth focuses on the conservation and preservation of natural resources and the environment, while promoting balanced utilization and sustainable economic growth.

c) The 13th National Economic and Social Development Plan (NESDP: 2023-2027)

Aligned with the 20-Year National Strategy, the NESDP (2023-2027) is a medium-term development framework for Thailand. It incorporates the SDGs, resilience, and SEP, focusing on structural reforms, policy adjustments, and mechanisms to create a society that nurtures human potential while keeping pace with global dynamics. The NESDP comprises thirteen benchmarks, categorized into four areas:

1. Production and service sectors.
2. Economic and social opportunity and equality.
3. Environmental sustainability and natural resource management.
4. National transformation, supported by capable human resources and effective governance.

Milestones related to biodiversity and sustainability include:

1. Establishing Thailand as a sustainable tourism destination.
2. Transitioning to a low-carbon society with a circular economy.
3. Reducing vulnerability to natural disasters and climate change.

d) The National Environmental Quality Management Plan (2023-2027)

Similar to the NESDP, Thailand’s Environmental Quality Management Plan (2023-2027) aims to establish an environmentally friendly society by conserving, restoring, and utilizing natural resources equitably. The Royal Gazette (2021) published this five-year plan, which outlines twelve guiding principles for environmental and resource regulation, including:

1. Sustainable development.
2. Ecosystem approach.
3. Precautionary principle.
4. Extended producer responsibility.
5. Polluters pay principle.
6. Beneficiaries pay principle.
7. Public-private partnerships.

8. Resource efficiency.
9. Good governance.
10. Human rights.
11. Integration.
12. Environmental justice.

The plan also promotes five strategic goals to optimize sustainable marine resource use, including:

1. Managing biodiversity and terrestrial resources to maintain balance.
2. Restoring and conserving marine ecosystems.
3. Establishing a climate-friendly society.
4. Controlling urban pollution.
5. Modernizing natural resource management practices.

e) The Climate Change Master Plan (2015-2050)

The Climate Change Master Plan (2015-2050) addresses critical climate change issues, focusing on adaptation, reducing emissions, and promoting low-emission growth. It includes three main areas of action:

1. Adapting to the impacts of climate change.
2. Reducing greenhouse gas emissions and promoting low-carbon growth.
3. Building institutional capacity.

The plan proposes measures to mitigate coastal erosion, including changes to coastal land use patterns and expanding biodiversity conservation areas as part of short- and medium-term goals.

f) Thailand's National Adaptation Plan (NAP)

Thailand's National Adaptation Plan (NAP) provides a framework for climate change adaptation, aiming to build resilience, reduce vulnerabilities, and increase adaptive capacity. The NAP aligns with Thailand's broader national frameworks, including the National Strategy (2018-2037), the Master Plan under the National Strategy, the National Economic and Social Development Plans, and the Climate Change Master Plan (2015-2050). It addresses six key sectors: 1) Water resource management; 2) Agriculture and food security; 3) Tourism; 4) Public health; 5) Natural resource management; and 6) Human settlements and security.

The NAP employs strategies to enhance resilience across these sectors, ensuring alignment with sustainable development principles.

Thailand's National Adaptation Plan (NAP) presents several different areas of focus that interact with coastal communities and sustain the health of these communities in the face of climate change (Department of Climate Change and Environment, 2023). Thailand states that it seeks to achieve the following goals, through the NAP, by 2037

- 2023-2027: Build a basis and instruments for policymaking and mainstreaming.
- 2028-2032: Strengthen policy instruments and mainstreaming across the priority sectors

- 2033-2037: Ensure climate resilience in the country's development actions

Table 1 presents the strategic directions, priority actions, and anticipated outcomes related to the management of marine and coastal ecosystems as outlined in Thailand's **National Adaptation Plan (NAP) 2023**. The focus is on building ecosystem resilience, reducing vulnerability to climate change, and integrating biodiversity and ecosystem services into national development.

Table 1 Strategic Guidelines and Expected Outcomes for Marine and Coastal Ecosystem Management under Thailand's National Adaptation Plan (NAP), 2023

Guideline/ Measures	Output
1) Conserve and protect marine and coastal resources, including increasing and rehabilitating mangrove areas for an ecological balance through a participatory approach.	Specific measures for the conservation and rehabilitation of marine and coastal resources in each marine and coastal community are developed with public participation, and integrated into the strategic plan of the area with effective implementation.
2) Support the conservation of endemic and endangered species in marine and coastal ecosystems affected by climate change, as well as prevent invasive alien species, which could become widespread due to the changing climatic conditions.	Research on breeding rare or endangered species are available, and regulations and measures for conserving and protecting biodiversity resources in marine and coastal ecosystems, especially threatened species, are in place.
(3) Expedite the designation of the EPAs in marine and coastal areas with fragile ecosystems and threats to biodiversity resources, which are outside the PAs.	Marine and coastal areas with fragile ecosystems and threats to biodiversity resources are designated as EPAs.
4) Assessment of Thailand's Ocean Health Index and development of surveillance and monitoring systems for changes to seawater as a result of climate change factors.	Surveillance and monitoring systems for changes to seawater as a result of climate change factors are developed.
(5) Prepare an integrated plan for coastal zone management across the country to reduce the impact of coastal erosion through a participatory approach.	Integrated plans for coastal zone management are developed comprising protection, restoration, or rehabilitation measures of coastal areas across the country, and mainstreamed into the area-based strategic plan in each locality with effective implementation.
(6) Strengthen the capacity of coastal areas to respond to and prevent the impact of storm surges.	Plans to mitigate the impact, establish evacuation routes in the event of storm surges in coastal areas are developed, and response manuals and drills are produced and conducted.
(7) Enable networks of people organizations, community-based	Networks of people organizations, community-based organizations, and

Guideline/ Measures	Output
organizations, and LAOs along the coastal zones to conserve and rehabilitate marine and coastal resources.	LAOs collaborate to develop measures on nature-based coastal restoration and participate in regulating the utilization of mangrove areas.

EPAs: Environmental Protected Areas; LAO: Local Administrative Organizations; PA: Protected Areas

To achieve the goals outlined in Thailand's National Adaptation Plan (NAP), the implementation of both sector-specific and cross-cutting measures is essential to ensure a synergistic and integrated approach to climate adaptation. These cross-cutting measures include the development of comprehensive databases, research, and technological innovations related to climate change adaptation. Additionally, the establishment of enabling mechanisms—such as regulatory frameworks, financial instruments, capacity-building programs, and incentives—is crucial. Strengthening the capacity, knowledge, and awareness of government officials and relevant stakeholders, including youth and the business sector, is also vital to foster a deeper understanding of climate risks and to empower all sectors to take effective adaptation actions.

g) The National Biodiversity Strategy and Action Plans (NBSAPs)

Building on previous biodiversity plans (ONEP 2015: ONEP 2017) such as the Master Plan for Integrated Biodiversity Management (2015-2021) and the Biodiversity Management Action Plan (2017-2021), Thailand is currently finalizing the National Biodiversity Strategy and Action Plans (NBSAPs) for 2023-2027, alongside a Long-term Biodiversity Strategy (2024-2050). The NBSAP framework follows three primary principles: the Sufficiency Economy Philosophy, urgency and challenge, and transformational change. It introduces new approaches and modifications to earlier plans, offering eight key guidelines:

1. A collaborative approach across all sectors of society.
2. Guidelines for achieving national biodiversity goals suited to the local context.
3. Balancing conservation with sustainable use.
4. Integrated ecosystem management and spatial planning.
5. Protecting the rights of stakeholders, with a focus on gender, youth, and vulnerable groups.
6. Cooperation in implementing relevant international conventions.
7. Raising awareness and promoting education on biodiversity.
8. Establishing financial mechanisms and securing additional funding sources.

The NBSAPs focus on three core strategies, each with specific goals, detailed in Table 2.

Moreover, ONEP (2024a) emphasizes that the success of the NBSAPs (2023-2027) relies on a robust implementation framework that integrates national biodiversity targets across all sectors. The four key mechanisms for success include:

1. Integrating sectoral plans.
2. Increasing stakeholder participation and awareness.

3. Leveraging financial and capital mechanisms to support implementation.
4. Monitoring and assessing plan execution.

Table 2: Three strategies and its targets under the NBSAPs

Strategy	Targets
Strategy 1: Strengthen conservation efforts by increasing the protection of important habitats and species through improving management practices, expanding protected areas and developing measures to protect threatened species. The strategy aims to increase protected areas by at least 30 percent of the country's total area by 2030 and to enhance conservation of important habitats and species at risk of extinction.	Four targets under strategy 1 include the following. 1) Goal 1: To reduce the loss of important biodiversity areas through effective spatial planning; 2) Goal 2: To increase the protection of important biodiversity areas and restore degraded ecosystems to ensure that natural areas remain healthy and can support species conservation, by increasing the area of conservation for biodiversity outside protected areas (OECMs) and establishing appropriate rehabilitation and management measures; 3) Goal 3: To enhance the conservation status of threatened species, by establishing appropriate protection and management measures; and 4) Goal 4: To enhance the resilience of ecosystems to climate change and pollution, by developing appropriate adaptation and management measures
Strategy 2: Promote sustainable use of biodiversity resources in a way that is fair and beneficial to local communities, including the sustainable management of agricultural, forestry, tourism, and fisheries areas to ensure balanced and non-destructive use. The strategy aims to increase the value and income of local communities from goods and services from biological resources, enforce regulations on access and benefit-sharing, and promote sustainable agriculture and sustainable forest management so that natural resources are used in a balanced and sustainable manner.	Three targets under strategy 2 include the following. 1) Goal 5: To increase the value and income of local communities from the bioresource base, by promoting a bio-economy; 2) Goal 6: To improve the sustainable management of production and service sectors, including tourism, by establishing appropriate management measures, promoting sustainable agriculture, forestry, resource management, fisheries and tourism; and 3) Goal 7: To establish mechanisms for access and benefit-sharing from genetic resources, by promoting the implementation of mechanisms and regulations for access and benefit-sharing.
Strategy 3: Integrate the importance of biodiversity into national and sectoral	Four targets under strategy 3 include the following.

Strategy	Targets
policies, planning processes, and development projects, by incorporating biodiversity into policies and plans in all development. Strategy 3 aims to focuses on integrating biodiversity into policies and plans of all sectors by promoting the establishment of at least five local biodiversity management plans and the disclosure of information on biodiversity of not less than 20 percent, which will enable national development and planning to coordinate and promote biodiversity conservation effectively.	1) Goal 8: To integrate biodiversity into the operations of all sectors, by developing guidelines for integrating biodiversity management into the operations of various sectors and developing local biodiversity management plans; 2) Goal 9: To mobilize financial resources for biodiversity conservation, by mobilizing financial resources from domestic and international sources; 3) Goal 10: Develop information and knowledge systems on biodiversity, including promoting awareness by developing information systems to support decision-making and raising awareness in various sectors; 4) Goal 11: Develop capacity and cooperation in technology transfer, including research, by exchanging knowledge and creating academic cooperation both domestically and internationally; and 5) Goal 12: Strengthen policy and legal frameworks for biodiversity by developing appropriate policy and legal frameworks.

h) The National Marine and Coastal Resources Management Policy (NMCRC) and Plan B.E. 2566-2570 (2023–2027)

The National Marine and Coastal Resources Management Policy and Plan B.E. 2566-2570 (2023–2027) emphasizes the conservation, protection, restoration, and sustainable utilization of marine and coastal resources (DMCR 2024a). It aligns with the global Sustainable Development Goals (SDGs) and Thailand's 20-Year National Strategy, ensuring that resource use is both efficient and equitable.

The plan's vision is:
"Marine and coastal resources are abundant, creating a balance between conservation and sustainable, fair utilization."

The plan sets out four main objectives:

1. To maintain the abundance of marine and coastal resources and achieve a balance between conservation and sustainable use.
2. To promote the sustainable and appropriate utilization of marine and coastal resources through inclusive participation from all sectors.
3. To enhance the efficiency of management mechanisms and tools at national, regional, and international levels.

4. To sustainably and systematically prevent and address coastal erosion problems.

The plan identifies four key goals:

- Coastal and marine areas are effectively and systematically managed to conserve biodiversity.
- Mangrove forest areas are increasing.
- Damage, risk, and impacts from natural disasters and climate change are reduced.
- The quality of Thailand's marine environment improves sustainably.

To achieve these goals, the plan outlines five sub-plans and guidelines, as detailed in Table **3**.

Table 3: Sub-plans and guidelines pertaining to the National Marine and Coastal Resources Management Policy and Plan (2023-2027)

Sub-plan	**Guidelines**
Sub-plan one: Conserve, protect, restore, and prevent marine and coastal resources with 5 guidelines	Guideline 1.1 Conserve and maintain marine and coastal resources as a basis for balanced and sustainable national development; Guideline 1.2 Restore and rebuild marine and coastal resource bases to reduce negative impacts from the country's social and economic development; Guideline 1.3 Drive action to achieve the goal of protecting and conserving biodiversity by 30% by 2030 [1] Guideline 1.4 Restoration of aquatic animal resources and maintenance of their abundance at a level that provides maximum sustainable productivity; and Guideline 1.5 Promote and support the intelligent and sustainable management of marine mineral and energy resources.
Sub-plan two: Promote and support the development of the blue economy based on the balanced and sustainable use of marine and coastal resources with 5 guidelines	Guideline 2.1: Increase efficiency in marine litter management and proactive control of marine and coastal pollution; Guideline 2.2 Support the development of marine and coastal industries to be environmentally friendly and sustainable; Guideline 2.3 Support and promote spatial management of marine and coastal resources [2]; Guideline 2.4 Effectively control fishing operations and promote sustainable fisheries development; and Guideline 2.5 Promote sustainable marine and coastal tourism

[1] DMCR has suggested significant projects to support this guideline include: 1) Project to drive the increase in protected areas and the use of other effective area-based conservation measures (Other Effective Area-based Conservation Measures or OECM); 2) Project to develop certification of protected areas of type LMMA (Locally Managed Marine Areas); 3) Monitoring and evaluation project for existing designated marine and coastal protected areas under the 2015 Promotion of Marine and Coastal Resources Management Act.

[2] DMCR have focused on supporting and promoting the spatial management of marine and coastal resources as a guideline for driving forward from the national reform plan on natural resources and the environment to manage marine environmental resources, conserve, protect, and restore in a balanced and sustainable manner to preserve biodiversity and ecosystems with all sectors' participation. This plan focuses on a project to drive the determination of marine and coastal resources areas in 23 coastal provinces to support and promote the spatial management of marine and coastal resources.

Sub-plan	Guidelines
	development and control tourism that creates negative impacts.
Sub-plan three: Strengthen the efficiency of tools and mechanisms to support integrated marine and coastal resource management with 7 guidelines	Guideline 3.1 Strengthen the role and capacity of the Provincial Marine and Coastal Resources Committee; Guideline 3.2 Integrate modern marine and coastal resources information management systems that cover all dimensions and serve as standards for use in management of all sectors; Guideline 3.3: Create economic tools and promote the integration of cooperation from various sectors in the management of marine and coastal resources; Guideline 3.4 Promote participation and support for coastal communities and local administrative organizations in terms of organization, networks, knowledge, roles, tools, and budget for management; Guideline 3.5: Continuously strengthen human resource potential, academic knowledge in research, and management of marine and coastal resources; Guideline 3.6 Develop and promote knowledge and understanding of sustainable use of marine and coastal resources to all sectors; and Guideline 3.7 Research and develop innovations in marine and coastal resources for sustainable resource management
Sub-plan four: Develop effective coastal erosion prevention management and reduce the impacts of climate change with 4 guidelines	Guideline 4.1 Promote and support integration between agencies and develop innovations to prevent and reduce coastal erosion in critical areas and important tourism areas of the country; Guideline 4.2 Develop legal tools and mechanisms for coastal erosion prevention and resolution that are comprehensive and complete in all dimensions.; Guideline 4.3 Conserve and restore marine and coastal resources to become effective carbon sinks; and

Sub-plan	Guidelines
	Guideline 4.4 Prepare a risk management plan for marine and coastal resources from various threats.
Sub-plan five: Strengthen international cooperation in the sustainable use of the oceans and marine and coastal resources with 3 guidelines	Guideline 5.1 Strengthen and support international cooperation in exploration, study, research, technology development and innovation related to sustainable management of the oceans and marine and coastal resources.; Guideline 5.2 Support international and regional cooperation to combat IUU fishing; and Guideline 5.3: Continuously strengthen the capacity of personnel and agencies responsible for international cooperation on oceans and marine and coastal resources

Annex 13: Key Sectoral Policies and Plans

• Marine Spatial Planning (MSP) Framework (2023)
Developed under the Department of Marine and Coastal Resources (DMCR) in coordination with the Maritime Interests Protection Policy Committee (MIP), this framework provides a strategic basis for spatially managing marine and coastal zones.
It promotes cross-sectoral coordination among agencies responsible for fisheries, energy, tourism, and transport, supporting the principles of ecosystem-based management and blue economy development. The MSP Framework serves as a foundation for forthcoming legislation and pilot MSP initiatives across the Gulf of Thailand and the Andaman Sea.

• National Master Plan on Waste Management (2016–2021) and Marine Debris Management Plan (2017–2021; updated 2023)
Led by the Pollution Control Department (PCD) under the Ministry of Natural Resources and Environment (MONRE), in close cooperation with the Department of Marine and Coastal Resources (DMCR), these plans address marine pollution originating from both land- and sea-based sources. They promote integrated waste management, circular economy approaches, and the reduction of single-use plastics, in alignment with the COBSEA Regional Action Plan on Marine Litter (RAP MALI). The updated 2023 plan introduces national monitoring indicators and strengthens multi-stakeholder collaboration among government agencies, local communities, and the private sector to achieve measurable reductions in marine debris.

• Thailand's Biodiversity Master Plan (2023–2027)
Implemented by the Office of Natural Resources and Environmental Policy and Planning (ONEP) under MONRE, this plan aligns with the Kunming–Montreal Global Biodiversity Framework (GBF) and builds upon the National Biodiversity Strategy and Action Plan (NBSAP). It focuses on restoring degraded habitats, expanding marine protected areas (MPAs), enhancing ecological connectivity, and mainstreaming biodiversity conservation into national and local planning. The plan also supports education, research, and awareness-raising to strengthen biodiversity knowledge and stakeholder engagement.

• Coastal Erosion Prevention and Management Master Plan (2023–2037)
Coordinated by the Department of Marine and Coastal Resources (DMCR) under MONRE and the Department of Public Works and Town & Country Planning (DPT) under the Ministry of Interior (MOI), this long-term plan provides a comprehensive approach to managing coastal erosion. It emphasizes integrated engineering solutions and ecosystem-based approaches, including mangrove restoration, shoreline stabilization, and community participation in coastal adaptation. The plan integrates scientific data, climate modeling, and local knowledge to inform decision-making and strengthen coastal resilience.