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1. Introduction

1.1 Aims of National Report

1.1.1 Inputs to the SCS-GOT TDA

The South China Sea (SCS) is a global center of shallow water tropical marine biodiversity and is one of the 64 Large Marine Ecosystems (LME) that supports unique habitats and ecosystems that are amongst the most biologically diverse shallow-water marine ecosystems globally. Large marine ecosystems are regions of ocean space of 200,00 km² or greater that encompasses the coastal areas from river basins and estuaries to the outer margins of a continental shelf or the seaward extent of a predominant coastal current. It is defined by ecological criteria including bathymetry, hydrography, productivity and trophically-linked populations (Duda and Sherman, 2002). The LME concept is for an ecosystem-based management approach focused on productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, climate and governance.

As an LME, the SCS is central to defining environmental sustainability and food security in the region. However, the richness and productivity of the SCS and associated environments like coastal communities are seriously threatened by pollution, overharvest, climate change, and habitat modification, resulting in high habitat loss rates and impairment of living resources' regenerative capacities. According to studies, the decadal rates of loss of coastal habitats from the SCS are high and increasing. In fact, each decade, around 30 percent of seagrass, 16 percent of mangrove, and 16 percent of live coral cover (Felix et al., 2025) is lost from this basin due to pressures associated with unsustainable patterns of use by the 270 million people that reside on the SCS's coast. Therefore, it is inarguable that the socio-economic impacts of environmental deterioration are significant for the economies of this region.

Recognizing that strategic actions are urgently needed to arrest the degradation of the environment of this marine basin, the countries of the region sought the assistance of United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF) in preparing a Transboundary Diagnostic Analysis (TDA) in 2000 of the issues and problems and their societal root causes as the basis for the development of a Strategic Action Programme (SAP), which was adopted at the inter-governmental level in 2008, representing the agreed common vision among the participating countries on targets and actions for reversing environmental degradation trends in the SCS. The SAP established a series of objectives and priority-costed actions for coastal habitats, land-based pollution management, and the over-exploitation of fish stocks in the SCS.

The TDA is a key component of the SAP for the marine and coastal environment of the South China Sea and Gulf of Thailand LMEs, serving as the scientific and technical foundation for identifying and understanding the root causes of environmental issues that transcend national borders. In contrast to the TDA-SAP Version 1.0 in 2000, which primarily focuses on status assessments, the TDA-SAP Version 2 for 2026 introduces a strategic shift toward forward-

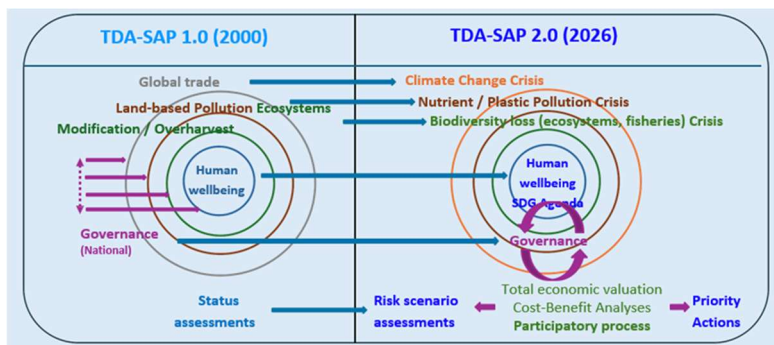


Figure 1.1. Composition of TDA-SAP 1.0 vs the updated 2026 TDA-SAP 2.0)

looking risk scenario assessments (Figure 1.1). This new version places greater emphasis on addressing the three (3) interlinked planetary crises namely climate change, nutrient and plastic pollution, and biodiversity loss. The revised framework aims to enhance the region's resilience by integrating these global environmental challenges into transboundary diagnostic and strategic action planning. For the Philippines, ensuring the accuracy and completeness

of its TDA inputs is essential to reflect local conditions, national priorities, and emerging environmental challenges within the broader regional context.

The participating countries of the region made a commitment and prepared the SAP. This commitment was further reinforced in 2016, when the six (6) countries in the region namely Cambodia, China, Indonesia, Philippines, Thailand and Vietnam signed a special Memorandum of Understanding (MoU), committing to cooperate with one another to implement the SAP. For the Philippines, the MoU was signed in 2016 by Atty. Jonas R. Leones, Undersecretary for Environment and International Environmental Affairs, for and on behalf of the then Secretary of the Department of Environment and Natural Resources, H.E. Ramon J.P. Paje.

This commitment provided a clear signal to the international community to support the financing of the SAP through various projects, including the project titled “*Implementing the Strategic Action Programme for the South China Sea and Gulf of Thailand (SCS SAP Project)*.” Later on, the project was financed and adopted by the GEF on November 03, 2016 and was implemented by the UNEP. The United Nations Office for Project Services (UNOPS), on the other hand, executed the project in partnership with the Ministries responsible for the environment in Cambodia, China, Indonesia, Thailand, and Vietnam. Meanwhile, for the Philippines, the one currently undertaking the SCS-SAP project is the Society for the Conservation of Philippine Wetlands, Inc (SCPW). The SCPW signed the Grant Service Agreement with UNOPS in November 2024 and since then has embarked on mobilization and full implementation of the project. The project has recently secured security clearance from the National Task Force for the West Philippine Sea (NTF-WPS). In response, the Department of Environment and Natural Resources (DENR) has issued a memorandum directing its concerned offices to extend support to the project’s overall objective. That is, to assist the governments of the participating countries in meeting the targets of the approved SAP 2008 through the provision of technical assistance as required in implementing national activities in support of the SAP; and the provision of strong regional co-ordination of the process of the SAP implementation for the marine and coastal environments of the SCS and Gulf of Thailand (GOT).

The Project Team was formed composed of consultants and technical staff with extensive and strong backgrounds on ecosystem management. The team frequently met online and in-person and gathered, reviewed and discussed various environmental reports focusing on the above-cited fields. They agreed to incorporate additional information on pollution hotspots, sensitive habitats, and some national frameworks and international initiatives that address governance.

Each consultant is tasked to lead the assessment and drafting of specific components of the Philippine TDA Report. These components include (i) Socio-economics and Climate, covering demographic trends, economic drivers and activities, and climate- and environment-related threats; (ii) Pollution, focusing on pollution sources and magnitude, nutrient loading, plastic waste, and other land-based transboundary pollution issues affecting the South China Sea; (iii) Ecosystems, which is subdivided into Coastal Wetlands, Coral Reefs, Seagrasses, and Mangroves, addressing biodiversity hotspots and sensitive areas, endemic, endangered, and threatened species, conservation priorities, as well as the valuation of economic losses; (iv) Fish, fisheries and aquaculture, concentrating on fisheries and ecosystem health indicators, including its management and conservation efforts; and (v) Governance, that explores economic and policy drivers, institutional setting and frameworks, legal and policy setting, and governance performance and effectiveness. Accordingly, each consultant is responsible for their assigned component, integrating scientific considerations, which were harmonized into the consolidated National TDA for submission to the regional process.

Through this coordinated approach, the Project Team ensures that all thematic areas are comprehensively addressed given available data, establishing a cohesive and evidence-based Philippine TDA Report that reflects both national priorities and the shared vision for the sustainable management of the LMEs in the SCS and GOT LMEs.

1.1.2 Analysis to Help National Reporting to SDG and other National Commitments

While the emphasis of this project is on supporting the participating countries to meet the targets of the SCS SAP, which must be considered globally significant, the project has also envisioned to contribute to the attainment of the global targets such as the Sustainable Development Goals (SDG), Agenda 2030 and the targets established by the Convention on Biological Diversity (CBD) under the Kunming-Montreal Global Biodiversity Framework (KMGBF). It is noted that alignment of SAP actions with CBD targets was a key consideration in SAP formulation. After all, the design of the results framework for the SAP project focuses as well in aligning outcomes with the KMGBF.

Importantly, the project seeks to contribute towards the achievement of the Sustainable Development Goals: 1, 6, 12, 13, 14, and 15.

Recognizing the urgency of achieving these goals given the identified threats, the countries bordering the SCS requested the assistance of the United Nations Environment Program (UNEP) and the Global Environment Facility (GEF) to prepare a Transboundary Diagnostic Analysis (TDA) as the scientific basis for a Strategic Action Program (SAP). The first regional TDA-SAP cycle culminated in the intergovernmental adoption of the SAP in 2008, setting objectives and priority actions to:

1. Conserve and restore critical coastal habitats
2. Manage land-based sources of pollution, and
3. Reduce the over-exploitation of fish stocks.

In contrast to the TDA-SAP Version 1.0 finalized in 2000, which largely concentrated on status assessments of coastal and marine resources, the forthcoming TDA-SAP Version 2 (2026) represents a strategic evolution. It introduces forward-looking risk scenario assessments (Figure 1) that allow countries to anticipate and prepare for emerging threats rather than only responding to current conditions. This second version highlights the need to confront the three interlinked planetary crises—climate change, nutrient and plastic pollution, and biodiversity loss—by embedding these global challenges directly into transboundary diagnostic and strategic action planning. For the Philippines, this means ensuring that its national TDA inputs are both accurate and comprehensive, so that local realities, national priorities, and evolving environmental issues are effectively reflected within the broader regional framework.

Overall, efforts will be made to align the agreed reporting systems with national reporting requirements to various international conventions and processes.

1.2 Major Water Related Environmental Problems

The Philippine coastal waters in the SCS-LME face multiple pressures that threaten the integrity of marine and coastal ecosystems. Land-based pollution, including nutrient loading, plastic waste, and other transboundary contaminants, degrades water quality and leads to eutrophication, which negatively affects seagrass beds and wetlands through smothering and reduced light penetration (Orth et al., 2006; Short et al., 2011). Coral reefs also suffer from sedimentation and nutrient enrichment, which encourage algal overgrowth and weaken reef resilience (Fabricius, 2005; Hughes et al., 2017).

Climate change and rising sea surface temperatures intensify these impacts. Warmer waters trigger coral bleaching and harmful algal blooms (HAB) when combined with nutrient loading (Hoegh-Guldberg et al., 2007; Peñafior et al., 2009), while also reducing seagrass productivity and causing large-scale die-offs (Waycott et al., 2009). Mangroves are increasingly vulnerable to sea-level rise, saltwater intrusion, and coastal erosion (Alongi, 2015; Primavera et al., 2019), while wetlands face shifts in salinity that threaten their ecological functions (Finlayson et al.,

2017). Ocean acidification further weakens coral skeletons and limits the growth of calcifying organisms, thereby diminishing reef structures that provide habitat for fish (Kleypas et al., 2006; Kroeker et al., 2013). Seagrasses are also affected, as changes in carbonate chemistry alter their productivity and associated biodiversity (Campbell & Fourqurean, 2014).

Extreme weather events such as stronger typhoons cause direct physical damage across ecosystems—breaking coral branches, uprooting seagrass meadows, eroding mangrove shorelines, and flooding wetlands (Villanoy & Yñiguez, 2024; Licuanan et al., 2019). Meanwhile, other natural hazards such as earthquakes and tsunamis destabilize seabeds, trigger submarine landslides, and generate powerful waves that can bury reefs and seagrass beds, displace marine life, and alter coastal landscapes (Satake, 2015; Imamura, 2018).

1.3 Biogeophysical Setting

1.3.1 Geomorphology and Geological History

The geomorphology of the Philippine Seas in SCS-LME is shaped by its tectonic and oceanographic setting within the Philippine archipelago, which comprises about 40% of the country’s Exclusive Economic Zone (EEZ) (VLIZ 2022, 2023; PD 1596, 1978; NGA 2004 as cited in Villanoy & Yñiguez, 2024). It features continental shelves, deep basins, reefs, and atolls—particularly around the Kalayaan Island Group (KIG) and western Palawan—formed through tectonic processes, reef accretion, and sedimentation. The Philippine Seas in SCS-LME evolved through seafloor spreading that began around 55–50 Ma and ceased by ~30 Ma, leaving behind extinct spreading centers such as the Central Basin Spreading Center and crustal features like the Benham and Gagua Rises (Taylor & Hayes 1980; Deschamps & Lallemand 2002; Li et al. 2021). Its semi-enclosed setting drives counterclockwise circulation that redistributes sediments and nutrients, while subduction and tectonic reorientations continue to shape its margins (Villanoy & Yñiguez, 2024). Seasonal monsoons and increasing typhoon frequency further influence erosion, sediment transport, and productivity, illustrating the dynamic geological and geomorphological history of the Philippine Seas in SCS-LME (Villanoy & Yñiguez, 2024).

1.3.2 Climatology, Present and Projected

According to the Modified Coronas Classification System (MCCS) of PAGASA, Philippine climate can be classified into four (4) types (Figure 1.2). The Philippine western seaboard predominantly exhibits a Type 1 climate, characterized by distinct wet and dry seasons—dry period from November to April and wet season for the rest of the year, with peak rainfall from June to September.

The Department of Science and Technology – Philippine Council for Agriculture and Aquatic Resource and Research Development (PCAARRD) also provided a complimentary classification system of the Philippine climate (Figure 1.3) through the Remote Sensing Information for Living Environments and Nationwide Tools for Sentinel Ecosystems in our Archipelagic Seas Program for Climate Change (RESILIENT SEAS Program, 2009-2012). It divides the seas surrounding the Philippine archipelago into 11 distinct clusters (David, 2012), each characterized by climatic and oceanographic conditions resulting from complex land-sea interactions in the coasts (e.g., precipitation, sea surface temperature, sea surface height, etc.) (PEMSEA, 2019).



Figure 1.2. Modified Coronas Classification System (PAGASA)

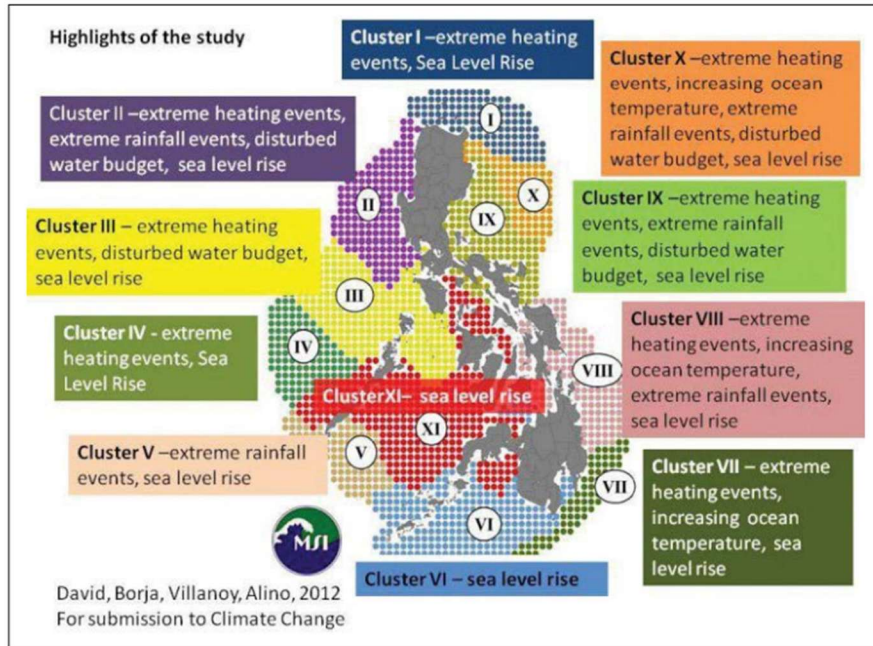


Figure 1.3. Climate Typologies in the Philippines (David, 2012 as cited by PEMSEA in the *National State of the Coasts*, 2019)

The country also experiences two (2) main monsoons: the stronger and more consistent northeast monsoon (*amihan*) which occurs from November to March, and the comparatively weaker and less predictable southwest monsoon (*habagat*) which prevails from June to September (Villanoy & Yñiguez, 2024). While the Type 1 climate is heavily influenced by the *habagat* (Villarin et al., 2016) the strong winds and cooler temperature associated with the *amihan* plays a significant role in enhancing primary productivity in the Philippine waters facing the SCS-LME. This is driven by wind jets funneled through the straits within the archipelago, generating localized upwelling zones—particularly along the west coast of Palawan—which may further enhance water column productivity (Villanoy & Yñiguez, 2024).

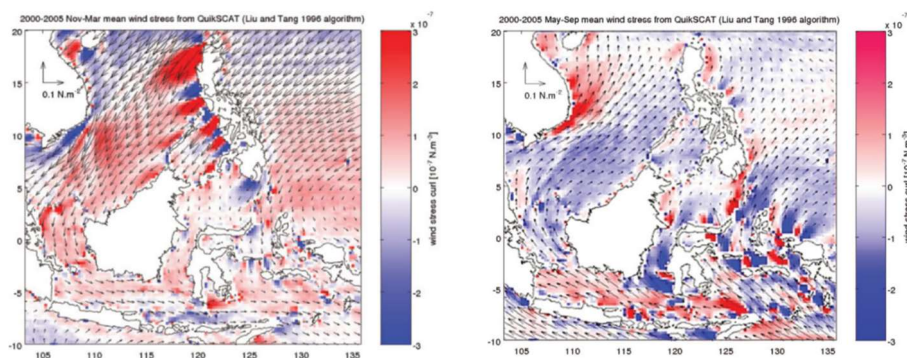


Figure 1.4. Wind Stress and Wind Stress Curl during *Amihan* (left) and *Habagat* (right) seasons

Positive wind stress curl areas (winds turning to the left) are associated with upwelling, and negative wind stress curl (winds turning to the right) areas with downwelling (Villanoy & Yñiguez, 2024).

To support climate adaptation and mitigation planning, PAGASA developed baseline (1981-2020) and projected (2021-2050) climate data for temperature and rainfall. Climate projections under various scenarios were generated using models from Coupled Model Intercomparison Project (CMIP) of the World Research Programme (IPCC, 2013b as cited in Villarin et al., 2016).

Temperature

The last 30 years (1981-2020) show that increasing temperatures have been observed in most parts of the country while some areas particularly in western Ilocos Region, eastern portion of Rizal province, and southern islands of Luzon experienced a slight decrease in temperature. Using these baseline data, projections for surface area temperature show that the country will experience significantly warmer climate towards the end of 21st century (2021-2050), ranging from 2.6°C up to 4.4°C increase from the average temperature and was seen highest for the month of May (DOST-PAGASA, 2024).

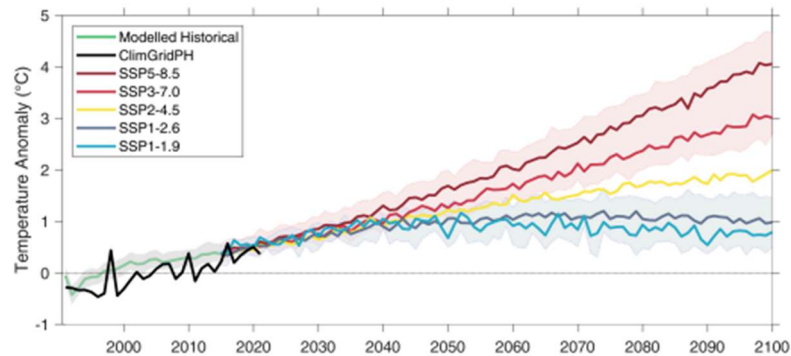


Figure 1.5. Time series of the annual mean temperature anomalies in the Philippines (DOST-PAGASA CMIP 6-BASED Climate Change Projections in the Philippines Report, 2024).

Rainfall

From the baseline period of 1981-2010, observed trend in rainfall revealed an increasing level in majority of the country particularly Luzon and Visayas. In December, increasing rainfall was observed in Luzon and Visayas and moves to Mindanao in January, coinciding with the northeast monsoon or *amihan* season. However, from July to October, western areas facing the SCS-LME experience heavy rainfalls due to the southwest monsoon or *habagat* season. Rainfall projections for 2021-2050 show a decrease in rainfall level in most parts of Luzon particularly from January to May but may experience about 5-10% increase in rainfall from June to December (except for the southern Luzon and most parts of Visayas in August, and most parts of Visayas and Mindanao in September, where a potential decrease in rainfall is projected (DOST-PAGASA, 2024).

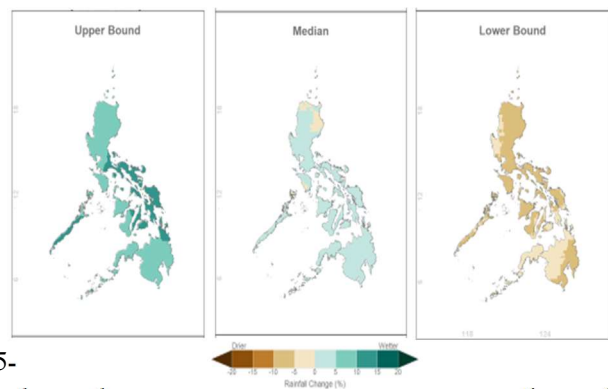


Figure 1.6. Range of projected changes in annual rainfall over the Philippines for 2021-2050 using baseline period 1981-2020 (DOST PAGASA CMIP 6-BASED Climate Change Projections in the Philippines Report, 2024).

The varying climatic conditions exert considerable impacts on the marine ecosystems. During wet seasons in June to September, increased precipitation contributes to greater surface runoff, leading to elevated nutrient loading, sedimentation, and coastal pollution (Gomez et al., 2016). Seagrass beds, which support nurseries for fish species and other invertebrates may be affected by sediment loading (Fortes, 2018). Surface run-off increases organic matter in the marine ecosystems leading to hypoxic conditions in coastal waters (Zhang, 2022). Meanwhile, the dry and hot seasons usually from March to May is associated with rising sea surface temperature (SST) which can trigger coral bleaching events (Licuanan et al., 2019). Elevated SST and ocean acidification also reduces calcification rates of corals, further threatening reef resilience (Fabricius et al., 2011).

Moreover, climate-driven changes in temperature, salinity, and nutrient availability influence fish spawning cycles and migration patterns, ultimately affecting fisheries productivity (Barut et al., 2004).

Due to its geographical location, the Philippines is also highly susceptible to tropical cyclones (PAGASA, n.d.). Approximately 19 to 20 tropical cyclones enter the Philippine Area of Responsibility (PAR) per year (Cayanan et al., 2011 as cited in Villarin et al., 2016). Intense typhoons can damage mangroves forests which are natural buffers against storm surges thereby compromising their ability to support vulnerable marine life (Primavera & Esteban, 2008).

1.3.3 Biogeography Endemic and Unique Marine Species

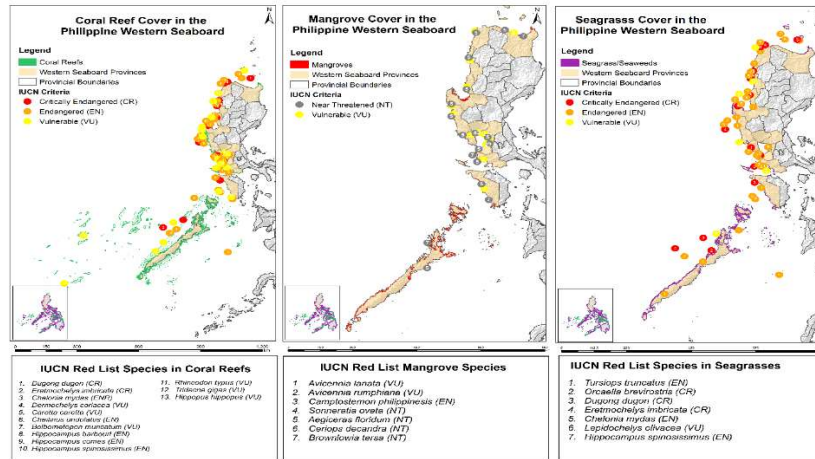


Figure 1.7. IUCN Red List Species of Endemic and Unique Marine Species in the Philippine Western Seaboard

The mangroves, seagrass and wetlands at Philippine waters at SCS-LME are home to a number of threatened mammals and reptiles species.

1.4 Assessment Methodology

1.4.1 Conceptual Framework

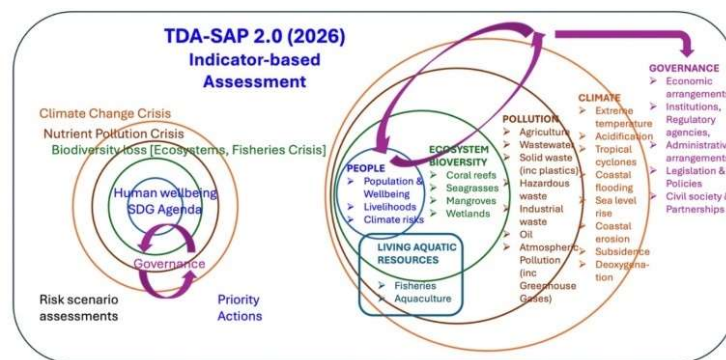


Figure 1.8. TDA-SAP 2.0 (2026) Indicator-based Assessment

The TDA SAP 2.0 (2026) is an indicator-based assessment. It is something that is metric and it indicates whether the status is good or bad. It also indicates whether the risk is high or low. In this TDA SAP 2.0, not everything is of metric indicator. In the case of governance, it also has qualitative descriptor of the state of governance relative to the major environmental issue. As shown in Figure 1.8, there are six components, namely:

- 1) People
- 2) Ecosystem Diversity: coral reefs, seagrasses, mangroves, and wetlands
- 3) Pollution
- 4) Fisheries or living aquatic resources
- 5) Impact of climate which affects all of the components – the people and ecosystems
- 6) Governance

The TDA SAP 2.0 intends to help governance informed not just on climate but the impact of climate on people and ecosystems and help governance be more attuned to the environmental crises that climate is imposing on people and ecosystems.

1.4.2 Subnational Geographic Divisions Used in the Analysis

This analysis uses provinces as the subnational geographic units, allowing localized variations to be captured and providing clearer insights for accurate interpretation and targeted recommendations.

Figure 1.9. depicts the political boundaries of the provinces along the Philippine western seaboard which face the SCS-LME, namely: Ilocos Norte, Ilocos Sur, La Union, and Pangasinan of Region I (Ilocos Region), Batanes and Cagayan of Region II (Cagayan Valley), Zambales, Bataan, Pampanga, and Bulacan of Region III (Central Luzon), the National Capital Region (NCR) which include 16 cities, Cavite and Batangas of Region IV-A (CALABARZON), and Occidental Mindoro and Palawan of Region IV-B (MIMAROPA). Understanding of the spatial dynamics and geopolitical considerations within the country facilitates a more comprehensive analysis of the socio-economic drivers, coastal and marine resource use, livelihoods, and governance frameworks relevant to the SCS-LME.

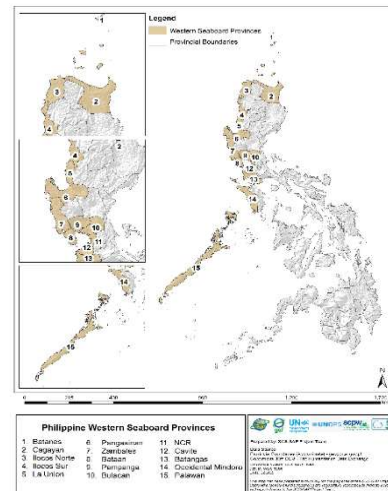


Figure 1.9. Political Boundaries of the Philippine Western Seaboard Provinces

1.4.3 List of Indicators by Components

Tables 1.1-1.5 below present only the indicators up to the second level. For the complete list of indicators per component, please refer to **Annex 1.A**.

- A. Socioeconomics and Climate-related Threats** – Assesses the vulnerability of coastal communities and livelihoods to socioeconomic pressures and climate change impacts

Table 1.1. List of Indicators for Socio-Economic and Climate

Socio-Economics and Climate Indicators	Components
Demographics	
SE1-1. Subnational Population	Number of Female Households Number of Male Households Total Households Total Population Growth Rate
SE1-2. Areas of Subnational First Level Administrative Region	Total Land Area (sq km)
SE1-3. Subnational Populations as % of National Population	% to Philippine Population
SE1-4. Subnational Region Areas as % of National Area	% to Philippines' Total Land Area (sq km)
SE1-5. Annual Population Changes	% Annual Change in the Population
SE1-6. Population Densities	Population Density (people/ sq km)

Socio-Economics and Climate Indicators	Components
SE1-10 Urbanization Rate	
SE1-11 Built Up Surface	Total Floor Area of Construction (sq km)
Human Well-Being	
SE2.1 Poverty	Poverty Incidence Among Families (%)
SE2.2 Contemporary Human Development Index (HDI)	Level of Literacy (Illiterate, Low Literate, Basic Literate) HDI Value and Classification

B. Pollution – Evaluates the sources, levels, and effects of land- and sea-based pollution on coastal and marine environments

Table 1.2. List of indicators for Pollution

Pollution Category	Parameter	Indicator
P-1. Marine and coastal water quality	PO1-1. Nutrient Pollution	
	PO1-2. Organic Pollution	Nitrate, Phosphate, Ammonia
	PO1-3. Coliform	BOD, DO
	PO1-4. Heavy Metals	Fecal, Total Coliform
	PO1-5. Water Quality	Cadmium, Chromium, Lead, Mercury
	PO1-6. Contaminants of Emerging PO1-7. Concerns (CEC)	TSS Microplastics
	P-2. Aquaculture / mariculture pollution	PO2-1. Fish Kill Events
PO2-2. Shellfish Advisories		Harmful Algal Blooms (HABs)

C. Ecosystems – Examines the status, trends, and resilience of critical marine and coastal ecosystems and their services.

Table 1.3. List of Indicators for Ecosystems

Properties and Variables	Data & Information needed
Mangroves And Wetlands	
MW-1.1 Geographic information	
MW-1.1. Name of area	Name of locality (coastal areas, estuaries, lagoon, ...)
MW-1.2. Co-ordinates	Latitude & Longitude central position of areas <50 Ha; GPS Boundary or number (min 4) of paired co-ordinates for larger areas; end points for linear strips.
MW-1.3. Total area	(Units Km ² or Ha)
MW-1.4. Areas of mangrove forest	(Units Km ² or Ha)
MW-1.5. Area of tidal flats	(Units Km ² or Ha)
MW-1.6. Area of seagrass beds	(Units Km ² or Ha)
MW-2. Social & use information	
MW-2.1. Ownership	Description: Federal, State, Community, private
MW-2.2. Management regime	Description: Land-use planning, Institutional framework, stakeholder co-ordination, forestry practices, restoration replanting, stakeholder investment, fishery practices.
MW-2.3. Current use	Description: Commercial, subsistence
MW-2.4. Potential use	Alternative livelihoods
MW-2.5. Significance/ national importance	Use designation in national/state master plans
MW-2.6. Protection status	Protection category (MPA, National Park...), total area, mangrove area, tidal flats area, seagrass area in hectare,
Coral Reefs And Seagrasses	

Properties and Variables	Data & Information needed
CS-1. Geographic Information	
CS-1.1. Name of area	Name of locality (islands, bay...)
CS-1.2. Co-ordinates	Latitude & Longitude central position of areas, GPS Boundary or number (min 4) of paired co-ordinates for larger areas; end points for linear strips.
CS-1.3. Area of coral reefs	Units Km ² or Ha
CS-1.4. Area of seagrass beds	Units Km ² or Ha
CS-1.5. Reef type	Fringing (mainland & island), barrier, atoll, patch, other
CS-2. Environmental state information	
CS-2.1. Present status	Live coral cover, dead coral cover, algae, abiotic (%) Seagrass cover (%)
CS-2.2. Present threats	<ul style="list-style-type: none"> • Sedimentation • Destructive fishing (no. of cases, both bombing & poisoning, reported per year) • Pollution (no. population & distance to the sources of pollutants) • Crown of Thorns (COT), years, infestation (density of COT, no. of cases, and infested areas) • Bleaching (2010, 2014-2017, 2019, 2024, others (% bleaching of live coral, % of mortality) • Others
CS-2.3. Trends of change	Increase or decrease of live coral cover and/or seagrass cover & density
CS-2.4. Future threats	Development plan & distance to the coral reef and/or seagrass area

D. Fish, Fisheries, and Aquaculture – Monitors the sustainability, productivity, and impacts of wild fisheries and aquaculture practices.

Table 1.4. List of Indicators for Fisheries

Indicator/Parameter	Units
FS-1. Annual Catch	Metric Tons
FS-2. Catch Value	USD

E. Governance – Reviews the effectiveness of policies, institutions, and cooperative mechanisms in managing marine and coastal resources.

Table 1.5. List of Indicators for Governance

Indicators	Components
GO-1. Economic Arrangements	GO-1.1. Political and Economic Drivers GO-1.2. National Budgetary Allocations GO-1.3. Investments (National, International) GO-1.4. Provincial Investment Profile GO-1.5. Sustainable Financing Initiatives
GO-2. Institutional Setting	GO-2.1. Institutions, Regulatory Agencies, and Administrative Arrangements

1.4.4 Assessing Risks to Ecosystems, People and Livelihoods, including those that are Related to Climate Warming, as Bases for Integrated Governance

The Philippine waters within the SCS-LME are subject to an increasing convergence of environment and socio-economic risks, both localized and transboundary in nature. Key drivers such as pollution, habitat degradation, and overfishing (cited in Chapter 7.3 of this report) collectively undermine the ecological integrity and sustainability

of marine and coastal resources in the country. These stressors are further magnified by climate change impacts of rising sea surface temperatures (SST), ocean acidification (Fabricius et al., 2011), and sea level rise. Collectively, this worsens existing vulnerabilities and introduces new systemic risks to ecosystems, communities, and marine-dependent livelihoods (UNEP, 2019; PEMSEA, 2018). A comprehensive assessment of such interconnected risks is crucial for integrated and evidence-based governance frameworks for the country’s marine and coastal ecosystems.

Ecosystems

Critical coastal ecosystems such as mangroves, seagrass beds, coral reefs, and wetlands provide essential ecosystem services including shoreline protection, fish nursery functions, water filtration, and carbon sequestration (McLeod et al., 2010; Barbier et al., 2011). These services play a crucial role in enhancing climate resiliency and adaptive capacity especially of coastal communities. However, the continued degradation of these ecosystems, driven primarily by anthropogenic pressures including land and water use change, reclamation, destructive practices, and pollution (cited in Chapter 7.3 of this report), poses significant threat to their functionality.

Furthermore, climate-induced stressors such as ocean warming, coral bleaching, and sea-level rise add to these existing pressures leading to substantial decline in habitat suitability and driving shifts in species distribution (Hughes et al., 2017). In this assessment, key areas such as Manila Bay, Lingayen Gulf, Batangas Bay and the Verde Island Passage, and Palawan have been identified as critical ecosystem hotspots where high biodiversity overlaps with commercial, industrial and tourism-driven pressures (Licuanan et al, 2019; cited in Chapters 3 and 4 of this report) raising both their risk and biodiversity significance and further highlighting the need for integrated management strategies.

Socio-Economic and Climate Vulnerabilities

Densely populated urban areas particularly Metro Manila in the National Capital Region (NCR) and adjacent provinces exhibit the highest exposure to climate-induced hazards such as flooding, storm surge, and sea level rise (ADB, 2021; cited in Chapter 2 of this report). These areas are also burdened by significant socio-economic and infrastructural vulnerabilities i.e., lack of disaster-resilient and climate-adaptive structures, pollution overload, and encroachment of informal settlement families (ISF) in hazard-prone areas which cumulatively increase their vulnerability to adverse climate-related events (World Bank, 2022).

On the other hand, while remote provinces such as Batanes are less exposed to hazards, their limited adaptive capacities—measured by lower incomes, high poverty indices, limited technology and infrastructure, and insufficient policy and institutional mechanisms—directly contribute to their increased vulnerabilities and overall risk (Yusuf & Francisco, 2009). Both scenarios, although contrasting, underpin the role of climate warming as a “risk amplifier”—intensifying the frequency and magnitude of extreme weather events and disproportionately affecting the marginalized and vulnerable sectors (IPCC, 2023).

Livelihood Risk

Fisheries in the Philippines remain to be a primary livelihood particularly in small-scale coastal communities. However, the sector continues to suffer from overfishing, habitat loss, and illegal, unreported, and unregulated (IUU) fishing (cited in Chapter 5 of this report) particularly in Fisheries Management Areas 5 (Palawan and Occidental Mindoro) and 6 (Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Bataan, Bulacan, Pampanga, Zambales, Batangas, Cavite, Occidental Mindoro) in this assessment. Degradation of mangroves, coral reefs, and fish spawning grounds directly affects fish productivity in addition to ocean warming which alters migration patterns and composition of fish species (DA-BFAR, 2020; Barange et al., 2018).

Without effective adaptive management, climate change will seriously threaten food security and livelihood stability of marine-dependent households. Therefore, climate change adaptation must be mainstreamed into policy measures, ensuring that these efforts complement and reinforce existing governance systems for sustainable fisheries and coastal resource use (Barange et al., 2018).

Risk-Based Integrated Governance

Globally pressing environmental challenges stem from complex socio-economic systems that transcend political, institutional, and governance areas. The fragmented structure of our existing governance frameworks is poorly equipped to manage cross-cutting issues, resulting in overlapping risks both at local and regional scales (PEMSEA, 2019; UNEP, 2019).

Hence, addressing the complex and interconnected nature of our country's social, economic, and environmental problems require systemic reform of institutional mechanisms. Governance frameworks must be data-driven, multi-level—linking local and national actions—and cross-sectoral, incorporating socio-economic dimensions with the three (3) interlinked planetary crises of climate change, nutrient and plastic pollution, and biodiversity loss (United Nations Framework Convention on Climate Change, n.d.). Furthermore, our governance frameworks should also adopt risk-based approaches that recognize the interaction between these drivers and the intensifying impacts of climate change. Such transformation is critical for minimizing socio-economic vulnerabilities and reducing ecological stress in our marine ecosystems (Raworth 2012; O'Neill et al. 2018 as cited in GEO-6 by UNEP, 2019; PEMSEA, 2019).

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Chapter 1 Annexes

Annex 1.A. List of Indicators by Component

Annex 1A.1. List of Indicators for Socio-Economic and Climate (Continuation)

Socio-Economics and Climate Indicators	Components
Blue Economy	
SE3.1. Subnational Regional GDP by Economic Sector (Agriculture, Manufacturing, Services)	<p>Agriculture, Forestry, and Fisheries Value Added at Current Price</p> <p>Manufacturing Value Added at Current Price:</p> <ul style="list-style-type: none"> • Manufacturing • Mining and Quarrying • Electricity, Steam, Water, and Waste Management • Construction <p>Services Value Added at Current Price</p> <ul style="list-style-type: none"> • Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles • Transportation and Storage • Accommodation and Food Service Activities • Information and Communication • Financial and Insurance Activities • Real Estate and Ownership of Dwellings • Professional and Business Services • Public Administration & Defense and Compulsory Social Activities • Education • Human Health and Social Work Activities • Other Services
Climate-Related Threats	
SE4-1. Number of Tropical Cyclones and Typhoons	
SE4-2. Number of Deaths Because of Tropical Cyclones and Typhoons	
SE4-3 Possible Total Damage Due to Hazards and Disasters (Exposed Population, Exposed Capital in USD)	<p>Storm Surge</p> <ul style="list-style-type: none"> • Typhoon Winds • Tsunami • Flooding • Landslide • Earthquake • Liquefaction • Volcanic Eruption • Wildfire • Drought • Other risks (epidemics, conflicts, etc)

Table 1.A.2. List of indicators for Pollution (Continuation)

Pollution Category	Parameter	Indicator
P-3. Wastewater and industrial	PO3-1. Wastewater	Generated, Collected and Treated
	PO3-2. Treatment Facility	Nitrate, Phosphate, BOD, COD, TSS, Fecal Coliform
	PO3-3. Pollution Load	

Pollution Category	Parameter	Indicator
P-4. Agricultural runoff	PO4-1. Fertilizer Use	N, P, K Fertilizer Nitrate, Phosphorus
	PO4-2. Pesticide Use	
	PO4-3. Nutrient Load	
P-5. Solid waste	PO5-1. Projected Generation	Illegal Dumps, Sanitary Landfill, MRFs
	PO5-2. Disposal Facilities	
	PO5-3. Top Plastic-Emitting Rivers in the Philippines	
P-6. Hazardous waste	PO6-1. Hazardous Waste	Generated, Collected and Treated Waste with Cyanide, Acid Wastes, Alkali Wastes, Waste with Inorganic Chemicals, Reactive Chemical Wastes, Inks/Dyes/Pigments/ Paint/Latex/Adhesives/ Organic Sludge, Waste Organic Solvent, Organic Wastes, Oil, Containers, Immobilized/Stabilized Wastes, Organic Chemicals, Miscellaneous Wastes
	PO6-2. Types of Hazardous Waste	
	PO6-3. Treatment Facility	
P-7. Oil pollution	PO7-1. Oil Spill	Major Incidents, Volume
P-8. Atmospheric pollution	PO8-1. Wet Deposition	Sulfate, Nitrate Sulfate (Particulate-bound), Nitrate (Particulate-bound)
	PO8-2. Dry Deposition	

Table 1.A.3. List of indicators for Ecosystems (Continuation)

Properties and Variables	Data & Information needed
Mangroves And Wetlands	
MW-3. Biological data	
MW-3.1. Present status	Vegetation Canopy Cover, Seagrass cover (% area)
MW-3.2. Natural/Managed	Proportions of total area natural and replanted
MW-3.3. Mangrove diversity	(True) Mangrove tree species Density (no ha ⁻¹)
MW-3.4. Seagrass diversity	Number of Seagrass species
MW-3.5. Migrating species	Species of mammals, birds
MW-3.6. SCS Endemic species	List species and abundance
MW-3.7. Endangered or threatened species (IUCN criteria)	List species and abundance if data available
MW-3.8. Source & sink of larvae	Location & types (breeding/nursery grounds of fishery species), density of larvae
MW-4. Stress-pressure information	
MW-4.1. Intrinsic/internal sources of change	<ul style="list-style-type: none"> Resident human population Natural e.g. frequency of typhoon throws, change in allochthonous sediment inputs, marine based flooding, erosion
MW-4.2. Extrinsic/external sources of change	Changes in catchment basin e.g. dam construction, water diversion etc.
MW-4.3. Rates of change, historical review	Rates of loss of cover and/or species over the period 2010-2024
MW-4.4. Social and economic drivers of change in environmental state	Description, quantitatively, if possible, e.g. population growth, immigration, income/livelihood, demand/ consumption, management regime)
MW-5. Economic valuation (based on Barbier, E.B. 1997)	
MW-5.1. Values of direct use	Timber, charcoal, living marine resource extraction
MW-5.2. Values of indirect use	Carbon sequestration, ecotourism, nursery areas for shrimps
MW-5.3. Values from environmental services	Coastal protection, sediment stabilization, water quality enhancement, contaminant sink, reduction of wave energy & erosion
MW-5.4. Value of investment	Restoration, replanting

Properties and Variables	Data & Information needed
MW-5.5. Values of potential (commercial) sustainable use	
MW-5.6. Total Economic Value	Local currency total (year?)
Coral Reefs And Seagrasses	
CS-3. Social & use information	
CS-3.1. Ownership	Description: Federal, State, Community, private, common property
CS-3.2. Management regime	Description: Land-use planning and coastal zoning, Institutional framework, stakeholder co-ordination, restoration, stakeholder investment, fishery practices
CS-3.3. Current use	Description: Commercial, subsistence, fishing ground, tourism and/or MPA
CS-3.4. Traditional use	Description of
CS-3.5. Potential use	Tourism and MPA (sustainable use)
CS-3.6. Significance/national importance	Use designation in national/state master plans
CS-3.7. Protection status	Protection category (MPA, National Park...), total area, coral reef area, seagrass area in hectare
CS-4. Biological data	
CS-4.1. Species diversity	<ul style="list-style-type: none"> No. of species and coverage of hard corals No. of species and coverage of soft corals No. of species and coverage of seagrasses
CS-4.2. SCS Endemic species	List species and abundance
CS-4.3. Endangered or threatened species (IUCN criteria)	List species and abundance
CS-4.4. Source & sink of larvae	Location & types (breeding/nursery grounds of fishery species), density of larvae
CS-4.5. Migratory species	List species and abundance
CS-5. Economic valuation (based on Barbier, E.B. 1997)	
CS-5.1. Extractive	Reef related fish landing (mt/\$\$) Subsistence fishery (no. of fishers dependent on reef – mt/\$) Commercially (live fish and fish landing – mt/\$)
CS-5.2. Non extractive (tourism)	No. of visitors. (\$ generated) No. of people involved in industry (income generated) – no. of chalets/hotels operators - no. ferry/boats operator - no. guide/agents Environment services Education Others
CS-5.3. Total Economic Value	Local currency total (year)

Table 1.A.4. List of indicators for Fisheries (Continuation)

Indicator/Parameter	Units
FS-3. Species Population Size	Number of Individuals
FS-4. Biomass	Kg/km ² (Tons/area)
FS-5. Stock Status Plots	%
FS-6. Fishing Effort	Number of Vessels or Hours Fished
FS-7. Catch per unit effort (CPUEs)	Kg per hour of trawling Kg/ 1000 hooks of Long Line
FS-8. Subsidies	USD or local currency
FS-9. Primary Production Required (PPR)	mgC·day ⁻¹ ·m ⁻²
FS-10. Marine Trophic Index	Level 1 - 5
FS-11. Fishing-in-Balance Index (FIB)	= 0; = More than 0; = Less than 0
FS-12. Catch from Bottom Impacting Gear	Percentage (%)
FS-13. Change in Catch Potential under environmental temperature change	Percentage (%)
FS-14. Aquaculture Products	Metric Tons
FS-15. Aquaculture values	USD

Table 1.A.5. List of indicators for Governance (Continuation)

Indicators	Components
GO-3. Legislation and Policies	GO-3.1. International Legal/Policy Frameworks & Forums <ul style="list-style-type: none">• United Nations Convention on the Law of The Sea (UNCLOS)• Fisheries Related Instruments• Biodiversity Related Instruments• Pollution Related Instruments• Climate Change Related Instruments GO-3.2. Regional Legal/Policy Frameworks & Forums
GO-4. Civil Society, Stakeholders and Partnerships	GO-3.3. National and Subnational Legislation and Policies GO-3.4. Current Development Plans, Policies GO-4.1. Key NGOs and Special Interest Groups GO-4.2. Trade Associations and Business Groups GO-4.3. Co-Management, Traditional Systems and Customary Rights GO-4.4. Decentralized Governance, Coastal Governance (Formal, Informal)

Socioeconomics and Climate-Related Threats in the Philippine Seas in the South China Sea Large Marine Ecosystem

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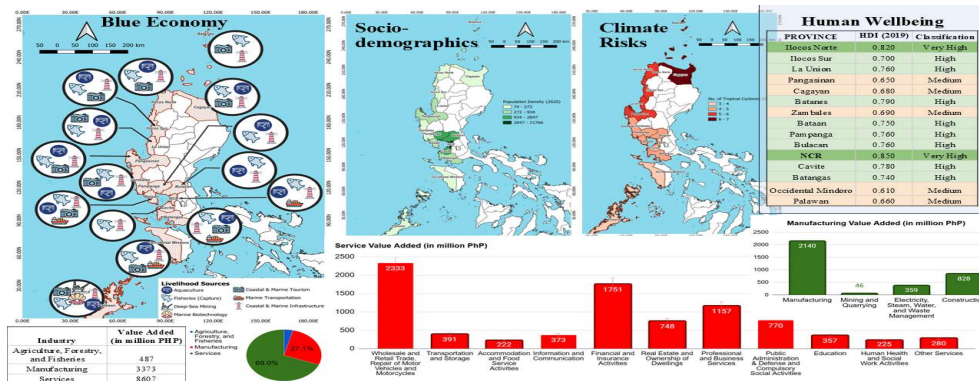
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Abstract

The South China Sea Large Marine Ecosystem (SCS-LME) is a biologically diverse tropical marine area that is vital to the surrounding coastal countries due to its high biodiversity and significant role in global fisheries, providing essential food security and economic benefits. However, these benefits are greatly affected by sociodemographic and environment-related threats contributing to the Triple Planetary Crisis: climate change, pollution, and biodiversity loss. This chapter presents the current status of the demographics, human well-being, and climate-related risks in the Philippine Seas in the SCS-LME. Using provincial data as a sub-national unit, this chapter analyzes these indicators focusing on the coastal provinces along the SCS-LME. Results found that the National Capital Region (NCR) has the highest population density at 21.7 thousand/sqm, followed by surrounding provinces, which provide better access to basic goods and services and more social and economic opportunities, reflecting a high human development index (HDI). While HDI trends are increasing from 2006-2019 across different localities, high poverty incident rates are observed in island provinces, such as Occidental Mindoro and Palawan, along with areas far from NCR like Pangasinan and Zambales. In terms of the blue economy, most of the industries and services are centered in these areas while food production particularly, agriculture, forestry, and fisheries are situated in rural and island provinces. Moreover, all provinces are vulnerable to various hazards and disasters, increasing the risks to the exposed population and capital across various localities. These are exacerbated by uncontrolled and excessive urbanization, particularly in NCR and neighboring provinces, which can lead to higher vulnerability to the impacts of climate change. The risk assessments from sociodemographic trends and climate- and environment-related threats provide bases for recommended mitigation measures and priority actions to build resilience and ensure sustainable and inclusive development in the localities along the SCS-LME.

Keywords: blue economy; climate change; human development; large marine ecosystem; socioeconomic

Graphical Abstract



2. Socioeconomics and Climate-Related Threats

The South China Sea Large Marine Ecosystem (SCS-LME) is a vital source of food, livelihood, and economy for several countries surrounding it, which are home to about 270 million people. The SCS-LME is heavily fished and the main source of animal protein for East and Southeast Asian regions. There are large reserves of oil and natural gas being utilized and still explored under its seafloor. It also serves as a hub for the blue economy containing some of the world's most important shipping routes, ocean transport and shipping ports, fishing industry, renewable (offshore wind) energy, coastal tourism, and community fishing ports.

However, these economic activities are facing challenges related to sociodemographic and climate and disaster risks. For instance, the rising sea levels, driven by climate change, can lead to coastal erosion and inundation, threatening infrastructure, water security, and food security, which is particularly problematic for communities that rely on marine resources for their livelihoods (Mishra, Gupta & Verma, 2025). Coastal areas are increasingly vulnerable to extreme weather events such as hurricanes, tsunamis, and storm surges as well as oil spillage, which can cause significant physical damage to marine and coastal ecosystems and disrupt local economies (Agaton et al., 2025; Laino & Iglesias, 2023). Meanwhile, the growing population and economic activities increase the number of people at risk from climate impacts with low-income coastal communities being particularly vulnerable due to limited adaptive capacity and reliance on natural resources for livelihoods (Yuan, Beard & Johnson, 2021). These are exacerbated by unregulated urban growth and development in coastal areas, particularly in developing and island countries, resulting in an increased pressure on ecosystems and reducing resilience to natural hazards (Tsilimigkas, Deligianni & Zerbopoulos, 2016). Moreover, challenges such as geopolitical tensions, overfishing, and habitat degradation hinder efforts to achieve sustainable economic growth in the region.

This component summarizes the sociodemographics, human well-being, blue economy, and climate-related threats, which are essential for formulating strategic actions, both at national and regional levels. The sub-national unit of analysis used in the study covers the data from provinces along Philippine Seas in the SCS-LME. The risk assessments from sociodemographic trends and climate- and environment-related threats provide bases for recommended mitigation measures and priority actions to build resilience and ensure sustainable and inclusive development.

2.1 Key Findings

- **Demographics** - The majority of the growing populations are situated in the National Capital Region (NCR) and its nearby provinces, which provide better access to basic goods and services, along with more social and economic opportunities. On the other hand, island provinces and those situated in farther regions from NCR, remain with fewer populations despite having vast land areas and natural resources.
- **Human Well-Being** - Ilocos Norte and NCR have very high human development index (HDI), while the rest of the localities have high and medium HDIs. Improving literacy rates and declining poverty incidences are expected to increase the HDI in the next years.
- **Blue Economy** - Most of the industries and services are centered in NCR and its nearby provinces, because of urban growth expansion from the metropolitan area. Food production is situated in rural areas, prioritizing agriculture, forestry, and fisheries for economic development.
- **Climate-Related Threats** - All localities are exposed to various hazards and disasters. Aside from the geographic location of the Philippines, continuous land conversions, illegal agricultural and fishing practices, mining and quarrying, improper waste management, congestion, and pollution, among others, result in environmental degradation. As such, there is little to no natural protection against hazards and disasters. Population and capital are increasingly exposed across various localities.

2.2 Current Status by Indicator Group

This section details the current status of the demographics, human well-being, blue economy, and climate-related threats for the provinces in the Philippine Seas in the SCS-LME.

2.2.1 Demographics

The Philippines has a total population of 109,035,343 in 2020. This makes the country ranked the 13th most populous nation across the globe and the second most populous country in the Association of Southeast Asian Nations (ASEAN) (Philippine Statistics Authority (PSA), 2021). Among the localities covering the Philippine Seas in the SCS-LME, NCR ranked the highest while Batanes ranked last in terms of population. Although all localities showed an increase in the population from 2015 to 2020, NCR and its nearby provinces like Cavite and Bulacan showed the most rapid population growth (PSA, 2020). Moreso, these most populous localities have smaller land areas; thus, higher population density that lead to congestion (Figure 2.1).

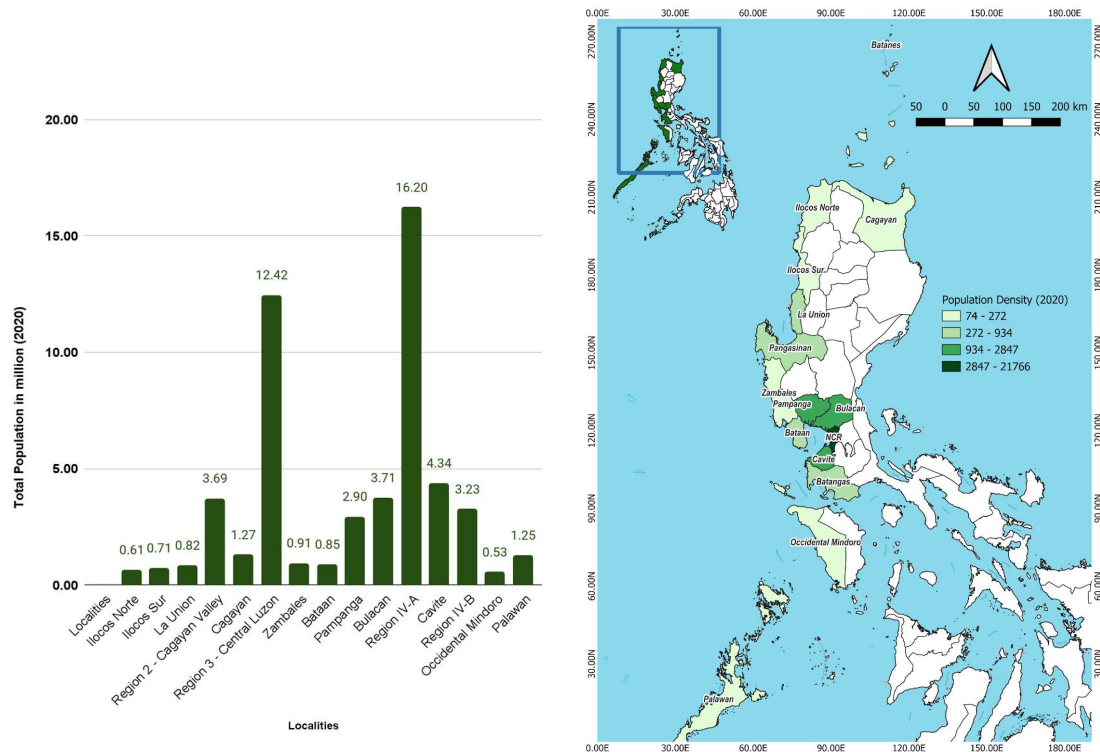


Figure 2.1. Population Data of Localities in 2020 (PSA, 2020)

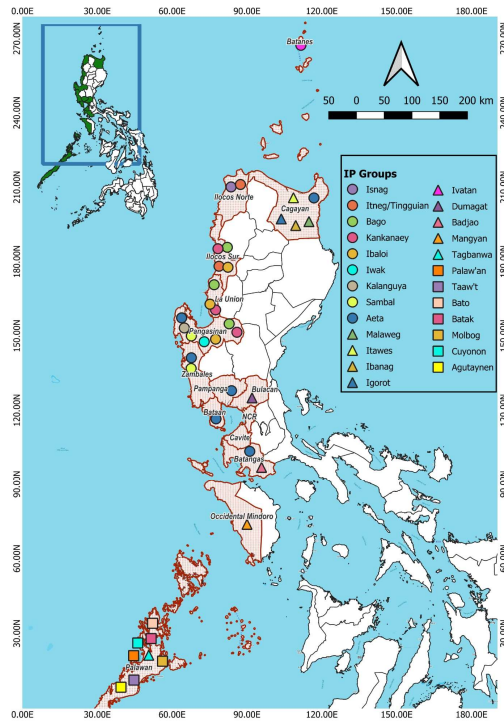


Figure 2.2. Indigenous Peoples (IP) Groups in Different Localities (PSA, 2020)

Studies also revealed that majority of the world’s population/ households opt to live in urban areas (Dodman *et al.*, 2023). Reasons include more access to services and opportunities, including technologies, telecommunication (D’Acci, 2021), transportation, and employment (Moro *et al.*, 2021). However, due to limited land area for the growing population, common practices include the conversion of forests and agricultural lands to residential, commercial, and industrial needs. If uncontrolled, this may lead to degradation of natural resources; hence, poor ecosystem services. Current manifestations include global warming, more intense and frequent disasters, poor sanitation, less access to safe water, and increased demand, yet lower supply of food (Dodman *et al.*, 2023).

On the contrary, rural provinces like Batanes have lower population. People are not attracted to live here since these will require more energy and resources to access different goods and services (Talubo & Saroj, 2019). Given the insufficient human capital and local budget, access to water supply (Aquino, Sanchez, & Roa, 2023), electricity, sanitation, and other essentials have been major issues in these localities. Although there are vast natural resources capable of providing more provision services for a smaller human population, due to geographic location, Batanes and similar island provinces are prone to many hazards and disasters, including earthquakes and typhoons (Hadlos *et al.*, 2023); thus, often resulting in socio-economic losses. Similar experiences can be observed by IPs situated in far-flung areas of provinces within SCS-LME (Macusi *et al.*, 2023) (Figure 2.2).

2.2.2 Human Wellbeing

Assessing the status of human wellbeing is also important consideration in developing strategic plans for SCS-LME as this recognizes the equitable access to diverse ecosystem services it provides and the socioeconomic impacts of conservation initiatives. Using different dimensions of human wellbeing, planners and policymakers can proactively understand future impacts of marine management decisions and co-create solutions with various stakeholders to ensure that marine conservation initiatives improve the welfare of the communities while attaining sustainable development goals (SDGs).

As per Republic Act No. 8425 of 1997, also known as Social Reform & Poverty Alleviation Act of the Philippines, the Department of Economy, Planning, and Development (DEPDev) defines poor families as households whose per capita income or expenses are lower than the per capita national family poverty threshold of Php 13,873 or USD 250 per month for a family of five (PSA, 2023, 2024). Among the localities covered by Philippine Seas in the SCS-LME, Ilocos Norte, Pampanga, and NCR have the least recorded poverty incidences, while Occidental Mindoro and Palawan have the highest (Figure 2.2). Priority programs, projects, and activities (PPAs) in Ilocos Norte included poverty reduction, improved agricultural productivity, and employment opportunities. This contributed to why the province had the least poverty incidence recorded (Adriano, 2024). On the other hand, economic development, especially in NCR and its nearby provinces, including Pampanga, aided in more access to basic goods and necessities to alleviate poverty (Ayoo, 2022). As for island provinces such as Occidental Mindoro and Palawan, studies showed that geographic isolation is a huge factor for less accessibility to basic goods and services (Deziel *et al.*, 2023; Zhou & Huang, 2023).

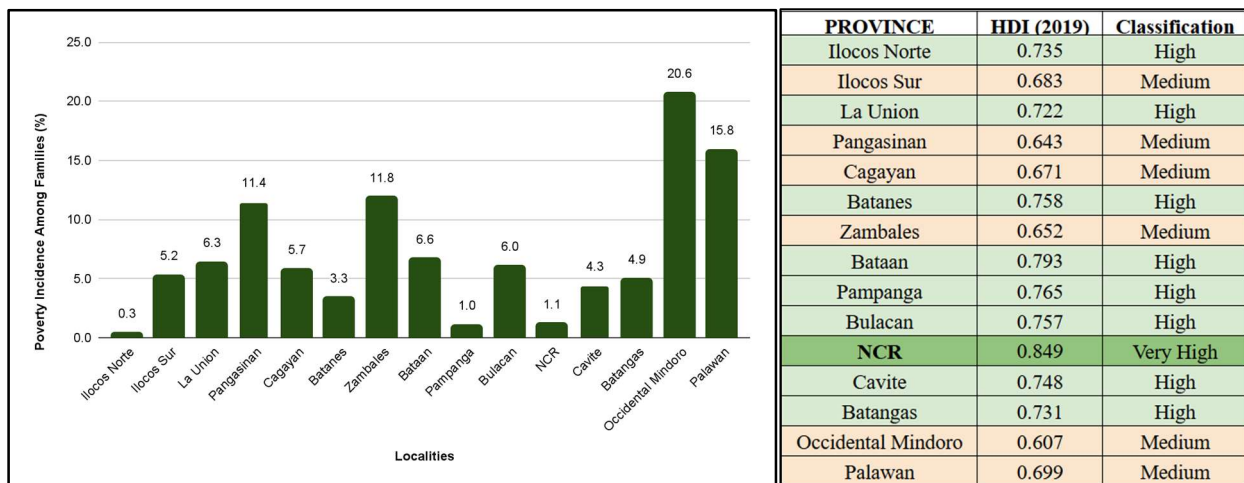


Figure 2.3. Localities' Poverty Incidence Among Families in 2023 (PSA, 2020; 2023)

Human Development Index or HDI, as a key metric of the United Nations (UN) for measuring human well-being and quality of life, uses indicators/ elements including per capita income, education, and life expectancy (Qori'atunnadyah, 2023). Following the United Nations Development Programme (UNDP) HDI classifications (very high: ≥ 0.800 ; high: 0.700-0.799; medium: 0.550-0.699; low: < 0.550), report by Human Development Network Foundation Incorporated (HDNFI) showed that NCR has very high HDI. Ilocos Norte, La Union, Batanes, Bataan, Pampanga, Bulacan, Cavite, and Batangas have high HDI results, while Ilocos Sur, Pangasinan, Cagayan, Zambales, Occidental Mindoro, and Palawan have medium HDIs (Figure 2.3).

Considering that the majority of the localities mentioned focused on economic development, as supported by the demographic results and analysis, this may have contributed to an increase in per capita income. Increase in income level also aided to longer life expectancy caused by improved access to health care services and nutrition. However, this may have been feasible through improved quality education, as the majority of higher-income jobs may apply to those with better educational backgrounds/ completed primary, secondary, tertiary, and/or postgraduate studies (Sart *et al.*, 2024).

2.2.3 Blue Economy

Blue economy refers to the sustainable use of ocean resources for economic growth, jobs, ocean health, and to improve livelihoods (Narwal *et al.*, 2024). It is composed of eight key sectors which all aim at using marine resources sustainably for economic growth and human well-being. These include (i) fisheries, (ii) aquaculture, (iii)

marine transportation, (iv) coastal and marine tourism, (v) deep-sea mining, (vi) coastal and marine infrastructure, (vii) renewable energy, and (viii) marine biotechnology.

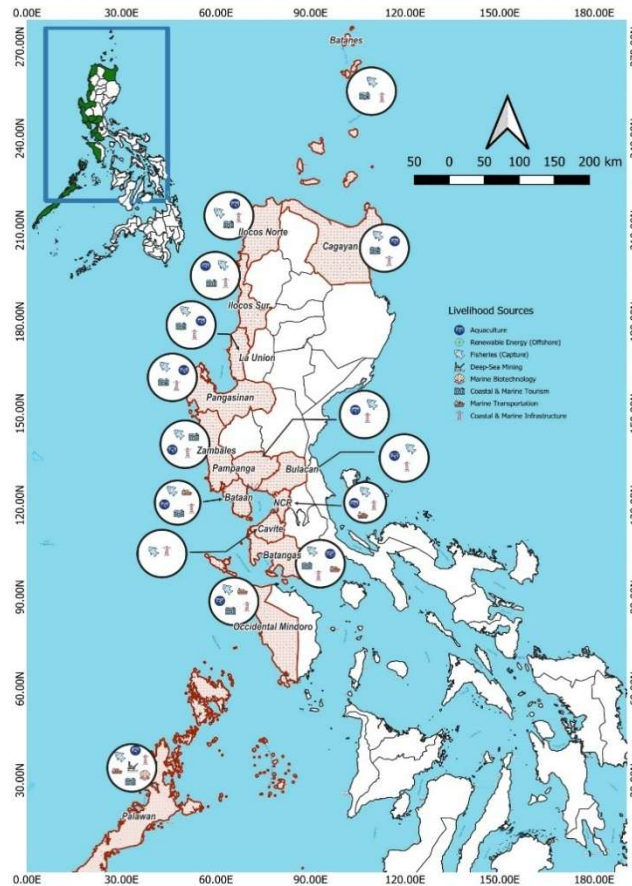


Figure 2.4. Blue Economy in Different Localities

As shown in Figure 2.4, all localities covered by Philippine Seas in the SCS-LME have coastal and marine infrastructure, which also aid in transportation and other economic activities. Among the major seaports are the Ports of Manila, Batangas, Subic (Zambales), San Fernando (La Union), and Irene (Cagayan), which serve as maritime transport hubs for local and international shipping industry.

Blue economy sectors common to the majority of the localities include coastal & marine tourism, aquaculture, and fisheries. On the other hand, deep-sea mining and marine biotechnology were evident in Palawan.

In terms of renewable energy, the World Bank estimated a 178 GW potential of offshore wind, which can significantly contribute to the country's climate goal and renewable energy target of 50% share by 2040. The Department of Energy (DoE) identified the potential offshore wind development zones in SCS-LME area such as Northwest Luzon (2-5 GW), NCR (up to 3 GW), Northern Mindoro (3-10 GW), and Southern Mindoro (20-36 GW).

Many Pacific countries recognize that in analyzing the total impacts of blue economy, ridge-to-reef approach has to be used due to interconnectedness of various sectors and their ecosystem services, including activities in the uplands which then affect the quantity and quality of services provided in the coastal areas and vice versa (Fache & Pauwels, 2022). Hence, all economic sectors comprising a locality were divided into (1) agriculture, forestry, and fisheries; (2) manufacturing, and (3) services. All of these were analyzed below.

Provinces such as Pampanga, Pangasinan, and Batangas have the highest value added at current price (2023) in terms of agriculture, forestry, and fisheries. This is evident considering that these provinces rely on the said economic ventures as primary sources of income/ livelihood (Provincial Government of Pampanga, 2013; Province of Batangas, 2021). On the other hand, Batanes, although a known rural area, had low values due to extreme weather conditions, which are not suitable for these economic activities (Hadlos *et al.*, 2023).

For manufacturing and services, NCR and its nearby provinces have the highest value added at current prices since these economic activities, requiring much energy, labor, and other resources, are attributed to metropolitan and urban areas. On the other hand, mining and quarrying, often in mountainous areas, are known only in selected rural areas such as Palawan and Zambales since these activities are not actively being promoted (Pascual *et al.*, 2022) because of numerous negative impacts. Moreover, Palawan LGU approved the ordinance on a 50-year mining moratorium due to increasing environmental concerns brought about by illegal mining and quarrying in this biodiversity hotspot (Ticke & Lagare, 2025).

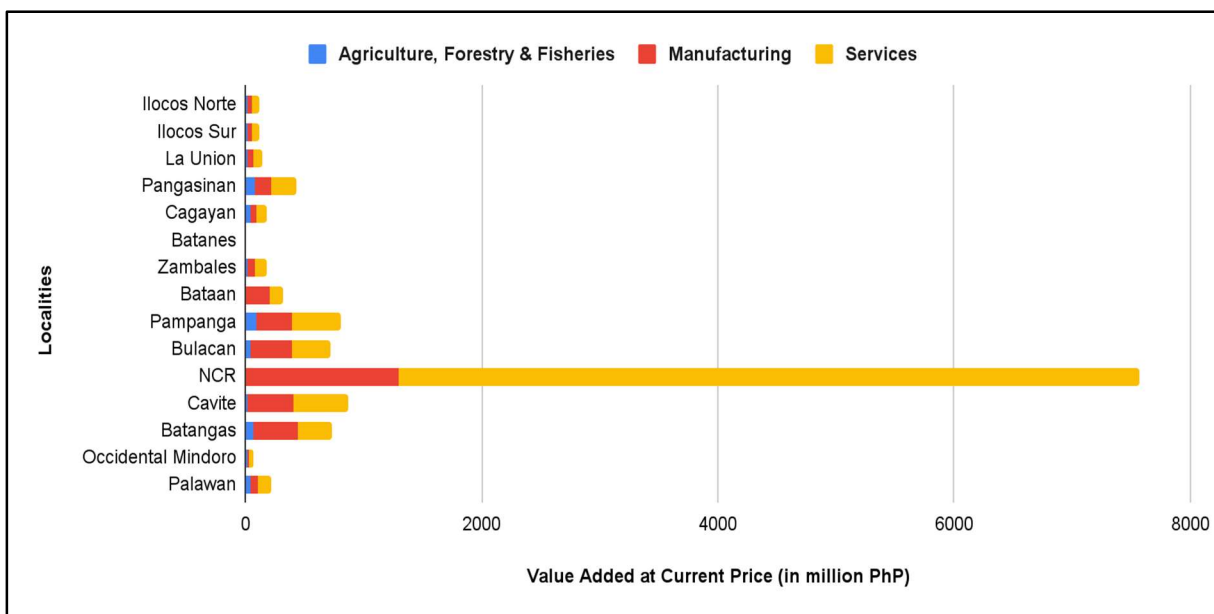


Figure 2.5. Value Added at Current Prices in 2023 of Economic Sectors in Different Localities (PSA, 2025)

2.2.4 Climate-Related Threats

According to the Department of Science and Technology-Philippine Atmospheric, Geophysical and Astronomical Services Administration (DOST-PAGASA) (2025), the Philippines has the largest number of tropical cyclones (TCs) entering the country per year than any other nation across the globe. This is shown in the map below, with localities surrounded by bodies of water experiencing frequent tropical cyclones and typhoons. The majority are in the northern part of Luzon, namely, Cagayan and Batanes, followed by Ilocos Norte, Ilocos Sur, La Union, and Pangasinan. Among these localities with Philippine Seas in the SCS-LME, NCR had the lowest number of TCs in 2024, yet still with the recorded 7 deaths. Batangas had the highest with 64 declared dead people. The majority of this was caused by Tropical Cyclone Trami (Kristine). The high population density and concentration of service infrastructure in the NCR and its nearby provinces can result in huge economic negative impacts if not properly mitigated.

In terms of the COVID-19 pandemic record of the Department of Health or DOH (2024), NCR had the highest recorded deaths, while Palawan, Occidental Mindoro, and Batanes had the lowest (Figure 2.7). This is evident

considering that NCR suffers from congestion (Lagundimao *et al.*, 2024); hence, higher exposure and contact with different people. On the other hand, island provinces are isolated and do not attract many migrants (Deziel *et al.*, 2023; Zhou & Huang, 2023). Hence, there is less entry and spread of the virus.

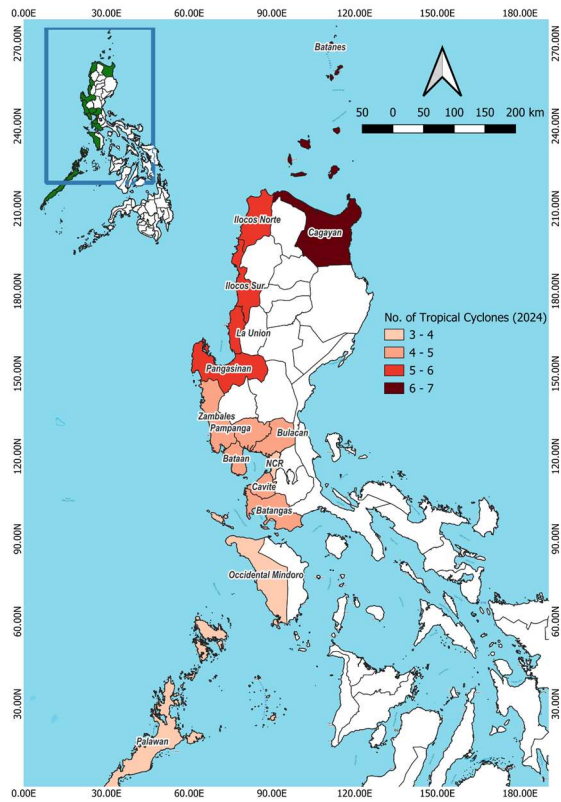


Figure 2.6. Number of Tropical Cyclones Affecting Localities in 2024 (CRED/UC Louvain, 2025)

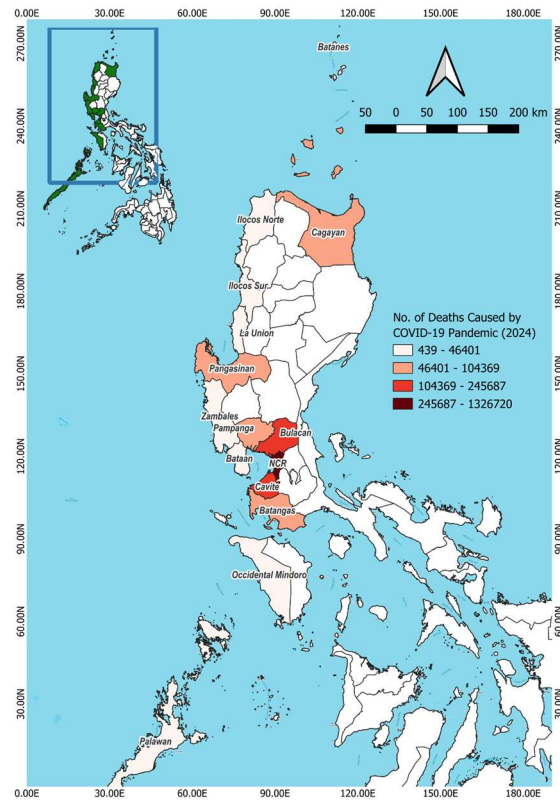


Figure 2.7. Number of Deaths Caused by COVID-19 Pandemic in Different Localities (DOH, 2024)

2.3 Discussion and Conclusions

2.3.1 Risk Assessment from Socioeconomic Trends

All of the local government units (LGUs) show increasing populations and it is still expected to grow in the coming years as shown in the figure below. However, NCR has a significantly higher population compared to other localities. This is given considering that it is composed of 16 cities and a municipality (PSA, 2025), and the majority of the population wanted to live in urban areas (Czaika & Reinprecht, 2022). Despite this, population increases in a slower pace over the past years. According to Gu *et al.* (2021), this is attributed to declining fertility rates. Among the factors include education, exposure of women to mass media, access to anti-fertility drugs, and employment/career priorities (Borzoiepour *et al.*, 2024).

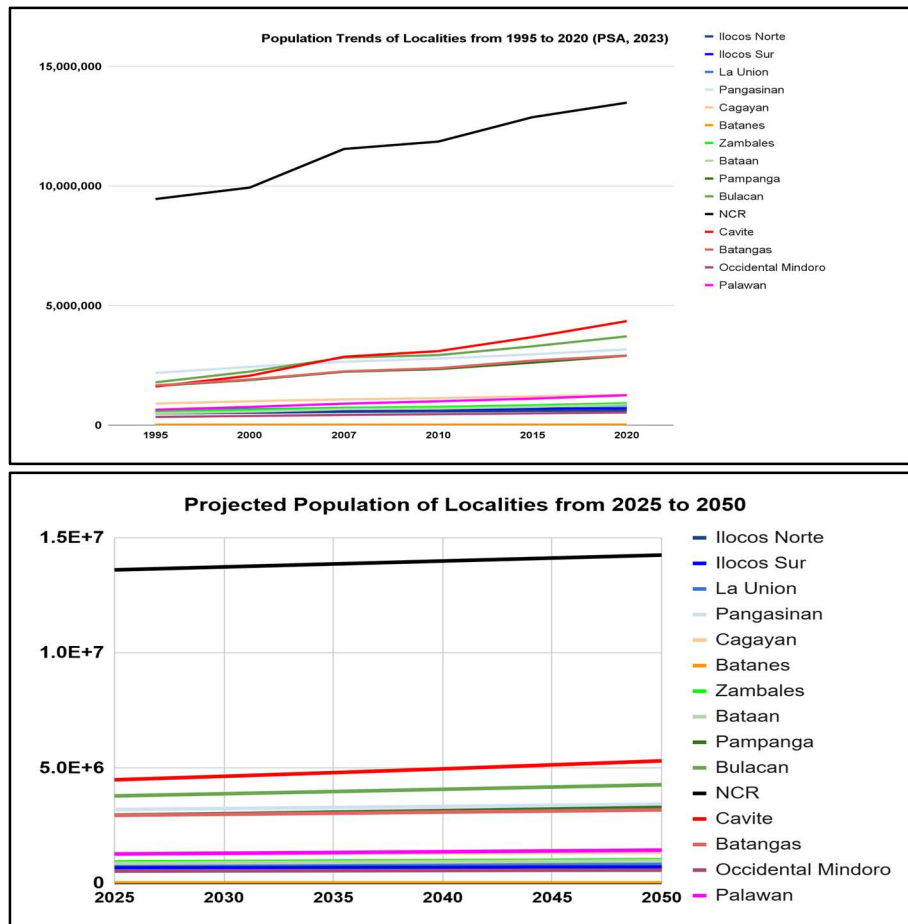


Figure 2.8. Population Trends and Projections of Localities from 1995 to 2050 (PSA, 2023)

Such access to information, education, and technology may also be a factor for decreasing overall poverty incidences in different localities. However, in the figure below, it can be observed that a sudden increase in poverty incidences occurred in 2021. This may be attributed to the COVID-19 pandemic, wherein many households suffered from less access to income/employment (Lavado et al., 2021). Many establishments and businesses shut down; hence, little to no money for food (Angeles-Agdeppa et al., 2022) and other necessities.

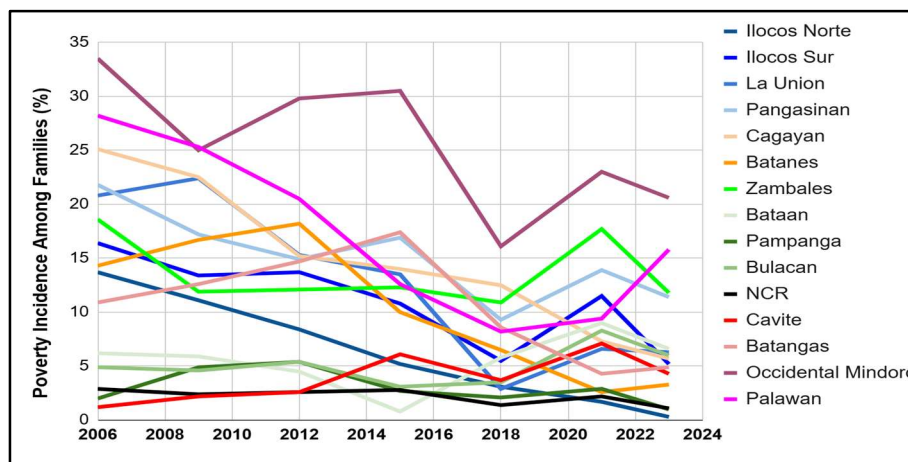


Figure 2.9. Trends of Localities' Poverty Incidence Among Families from 2006-2023 (National Statistical Coordination Board, 2013; PSA, 2018, 2021, 2023; Siosion, 2022)

Overall, increasing HDI trends can be observed from 2006-2019 across different localities (Figure 2.10). The NCR and nearby provinces had higher HDI results compared to those farther from the metro. However, a significant increase in the HDIs of these provinces far from the NCR can be observed from 2012 to 2019. This can be attributed to a shift in priority, such as Ilocos Norte’s administration focus on health, education, and employment (Adriano, 2024).

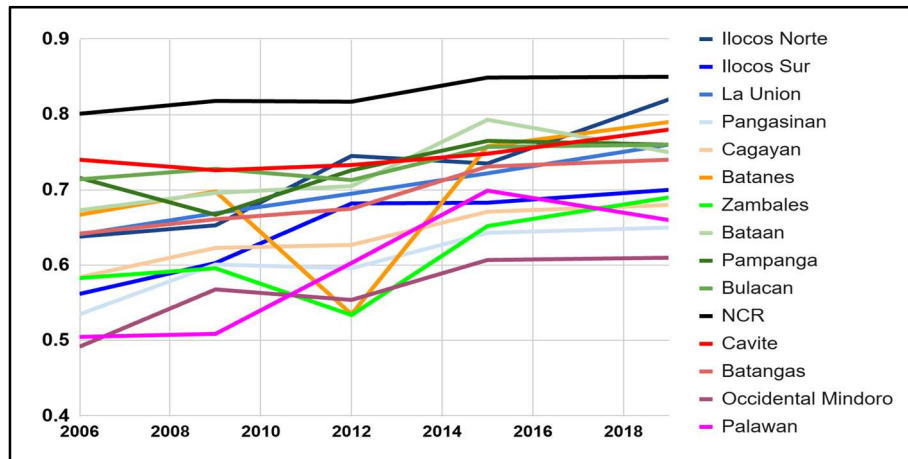


Figure 2.10. Human Development Index (HDI) Trends of Localities from 2006-2019 (PSA, 2020, 2023)

Given that education is one of the indicators, it is expected that there can be an HDI increase considering that the majority of the population was basically literate (able to read, write with understanding, and compute) in the 2024 PSA result of Functional Literacy, Education, and Mass Media Survey (FLEMMS) as presented in the figure below. However, considering that there are still illiterate (cannot read and write) and low literate (can only read and write) populations across different localities, there should be efforts to improve education access such as additional public schools, libraries, and teachers along with offering more scholarships and incentives (e.g., free uniforms, school supplies, tablets, and internet connectivity in schools).

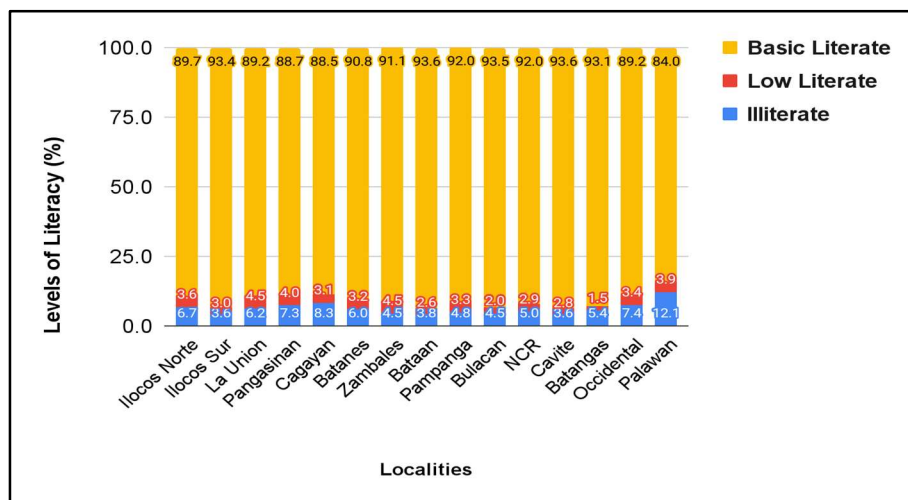


Figure 2.11. Localities’ Levels of Literacy (PSA, 2024)

In terms of employment and livelihood components, rural areas contribute the highest economic outputs for agriculture, forestry, and fisheries. However, according to the National Economic and Development Authority or NEDA (2021), it is evident that primary production had the least economic contribution as compared to manufacturing

and services which are centered in cities and urban areas. Hence, a contributing factor as to why rural areas have higher poverty incidence compared to NCR and its nearby provinces.

Overall, increase in value added at current prices from 2018 to 2023 is evident for all economic sectors. However, all experienced sudden decrease during the period of COVID-19 pandemic. Urban areas were recovering their manufacturing and services while some rural areas also ventured on increasing economic efforts centered on these aspects during the post-pandemic. If this continues, increase land conversion for commercial and industries may occur. Hence fewer agricultural lands in the future which may threaten supply and demand of primary production for the increasing population.

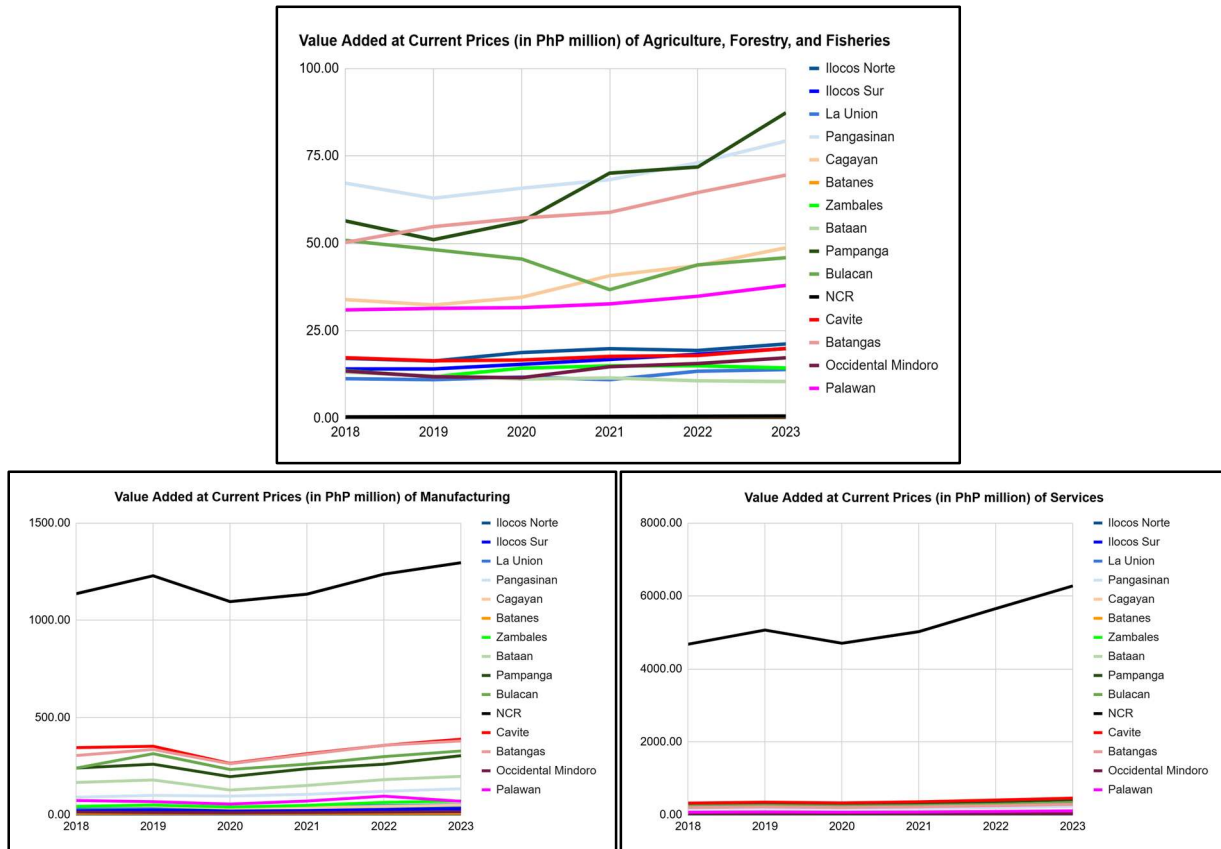
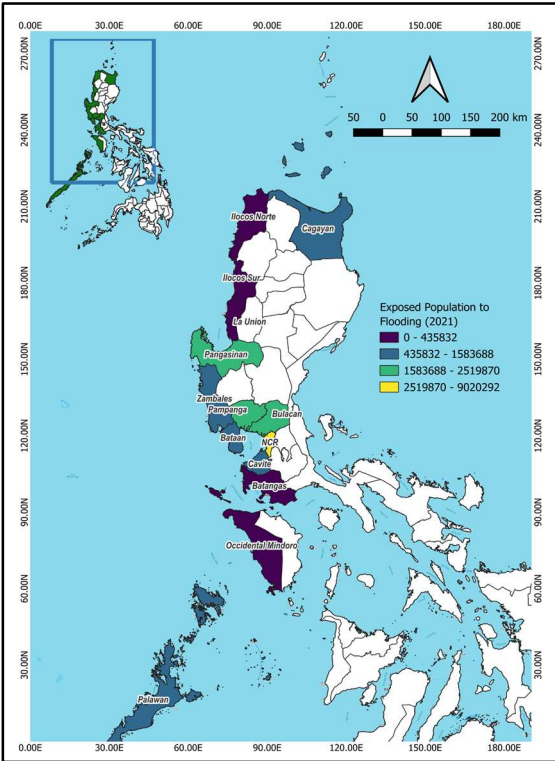
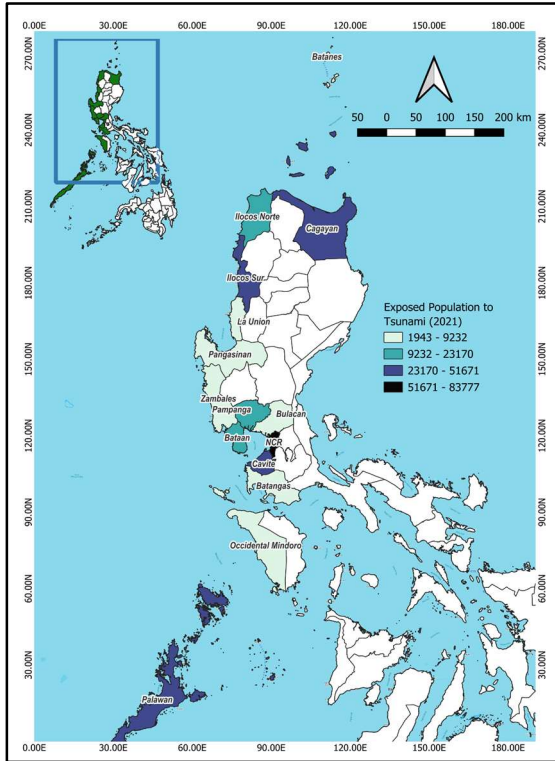
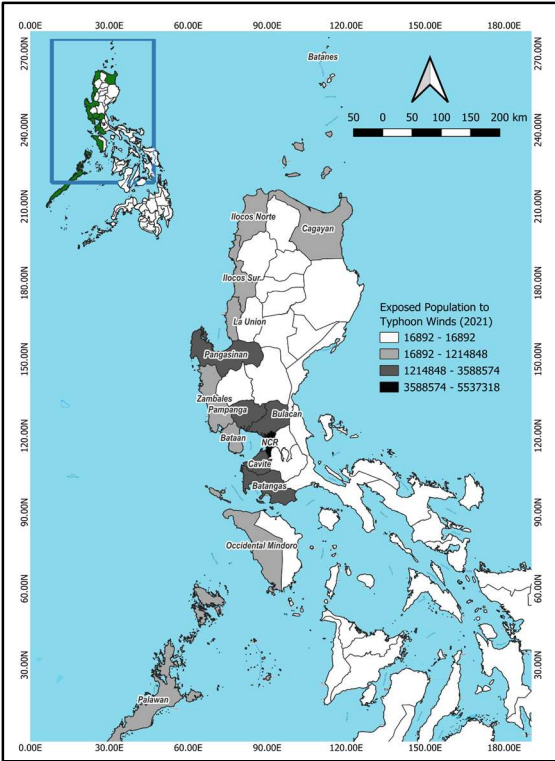
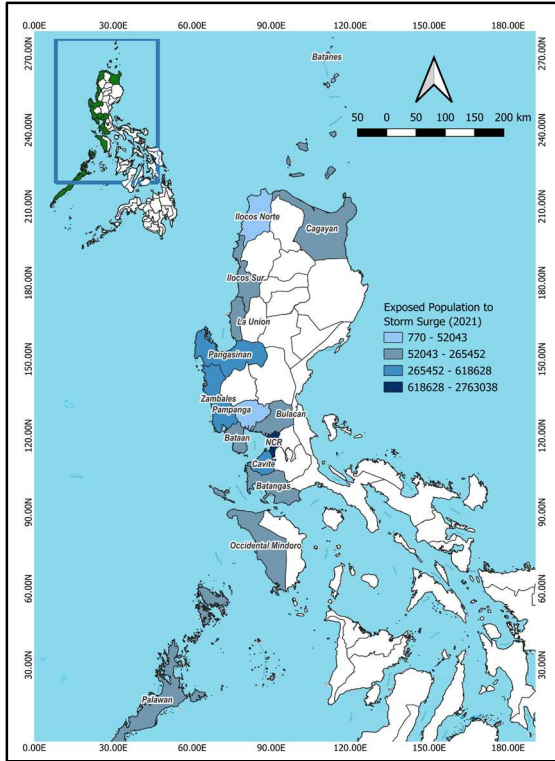
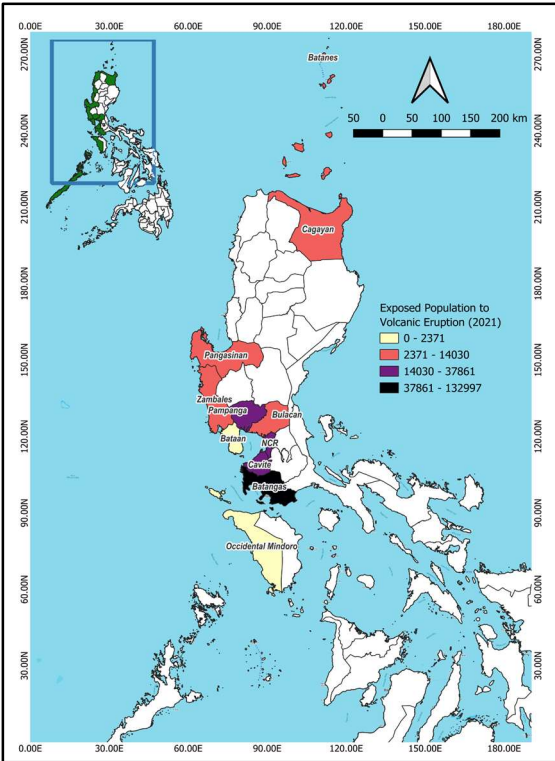
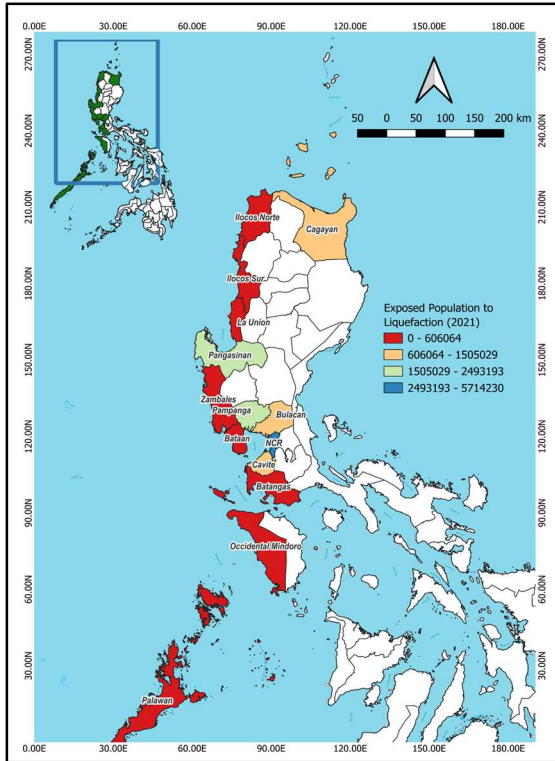
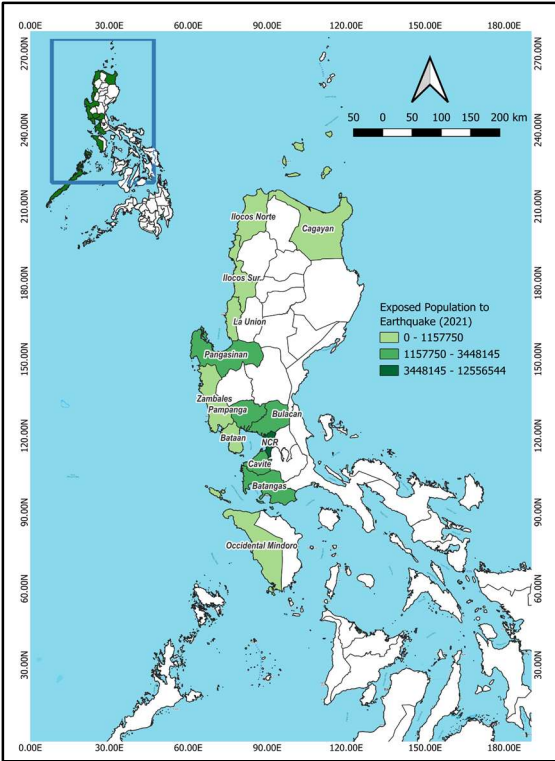
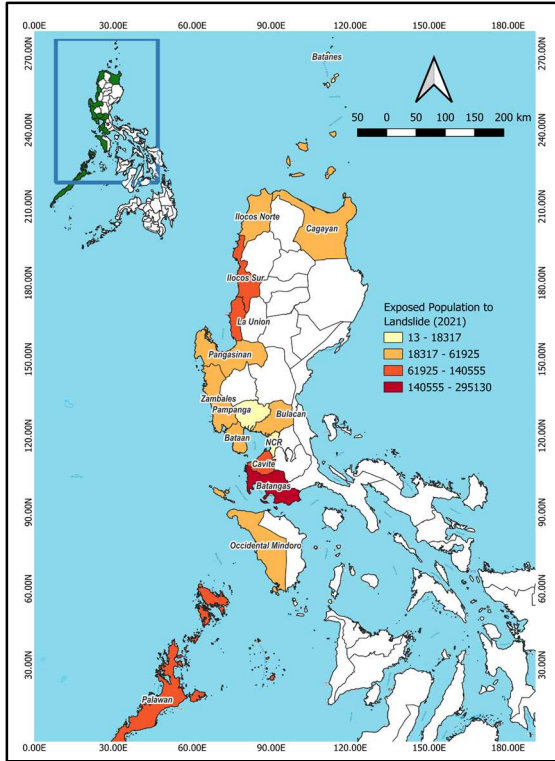


Figure 2.12. Economic Sector Trends of Value Added at Current Prices from 2018-2023 (PSA, 2025)

2.3.2 Risk Assessment from Climate- and Environment-Related Threats

The Philippines is an archipelago situated in the Pacific Ring of Fire. Thus, it is exposed and vulnerable to many hazards and disasters, especially hydrometeorological and geological in nature (Morante-Carballo, 2024). This is shown in the maps below, where all localities were exposed to many types of hazards. The NCR had the highest exposed population, followed by its nearby provinces. On the other hand, Batanes had the lowest, considering that it also had the least population among the provinces in the Philippines.





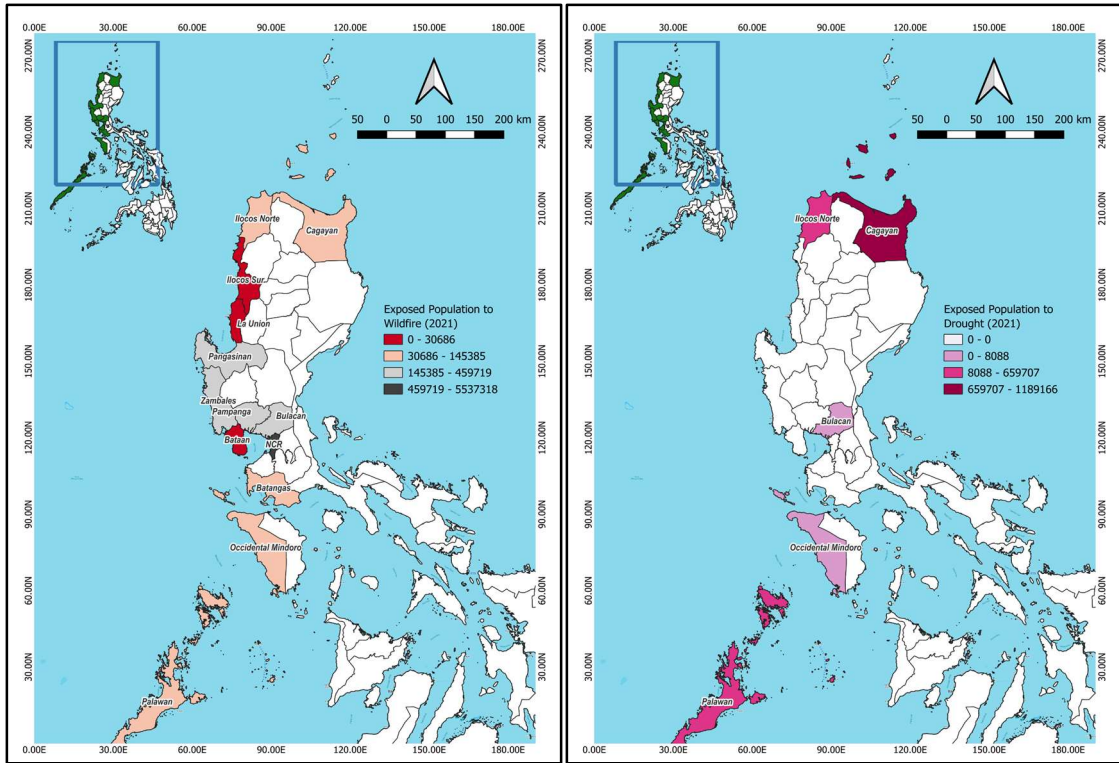


Figure 2.13. Exposed Population to Different Hazards of Localities in 2021 (Pacific Disaster Center, 2021)

Aside from natural hazards, human-induced maritime disasters such as oil spill is also evident. Localities experiencing shipping traffic and those with seaports are more prone to oil spill incidents. Hence, as seen in the figure below, NCR had the highest overall frequency of recorded oil spill.

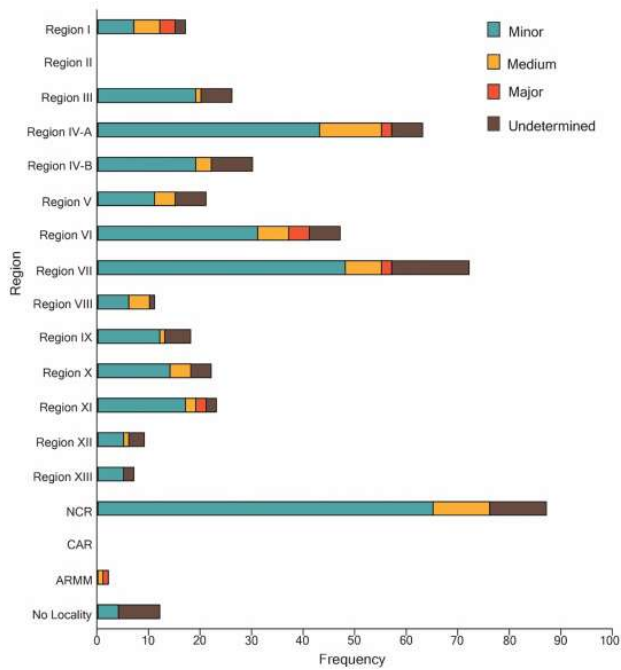


Figure 2.14. Frequency of Oil Spill Incidences Across Regions from 2000 to 2021 (Alea *et al.*, 2022)

Climate change is also a major concern that may intensify disasters. In fact, it is expected that there will be higher average temperatures in the coming years. In Figure 2.13, the thick black line represented the baseline data from 1990 to 2020. SSP are possible future scenarios of the Philippines. SSP1-1.9 and SSP2-2.6 showed that if the country continues with its sustainability pathways, temperature increases from 0.5 °C to 1.5 °C will still be experienced at the end of the 21st century. On the other hand, if SSP3-7.0 and SSP5-8.5 happen due to continuous vast emission of greenhouse gases (GHG), temperature may increase from 2.6 °C to 4.4 °C (DOST-PAGASA, 2024). Such impacts of global warming can lead to more frequent and intense hazards and disasters.

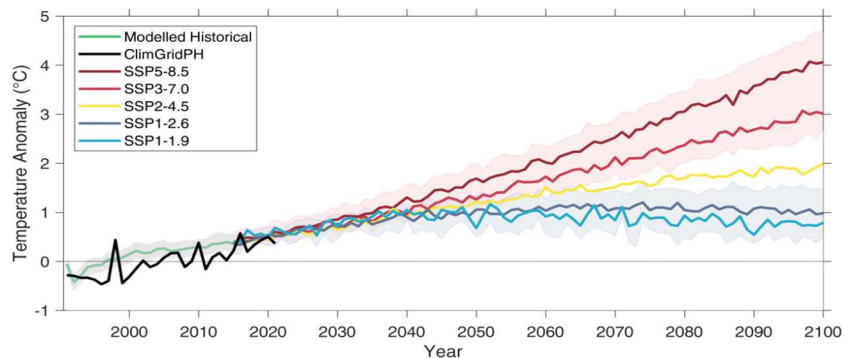


Figure 2.15. Time Series Showing the Annual Mean Temperature Anomalies in the Philippines (DOST-PAGASA, 2024)

In terms of rainfall projections, there are numerous scenarios for the Philippines. Rainfall in upper bound indicates that annual rainfall may increase to around 15% during the mid-21st century (2021-2050). Most areas in Luzon may have wetter conditions. On the other hand, for the median (50th percentile), this shows that rainfall in the country may become wetter by about 5% in comparison to 1981 to 2010. Lastly, for the lower bound (25th percentile), a projected decrease instead of about 10%-15% may be experienced across various localities. Excluding Zambales to Ilocos Sur, along with central part of Palawan, majority of Luzon cities and provinces will experience great reduction in rainfall (DOST-PAGASA, 2024). All these scenarios still pointed out a worse future due to more intense and heavy rainfall or a warmer country. Hence, disaster mitigation and preparedness efforts should be done to avoid or lessen the worse future scenarios.

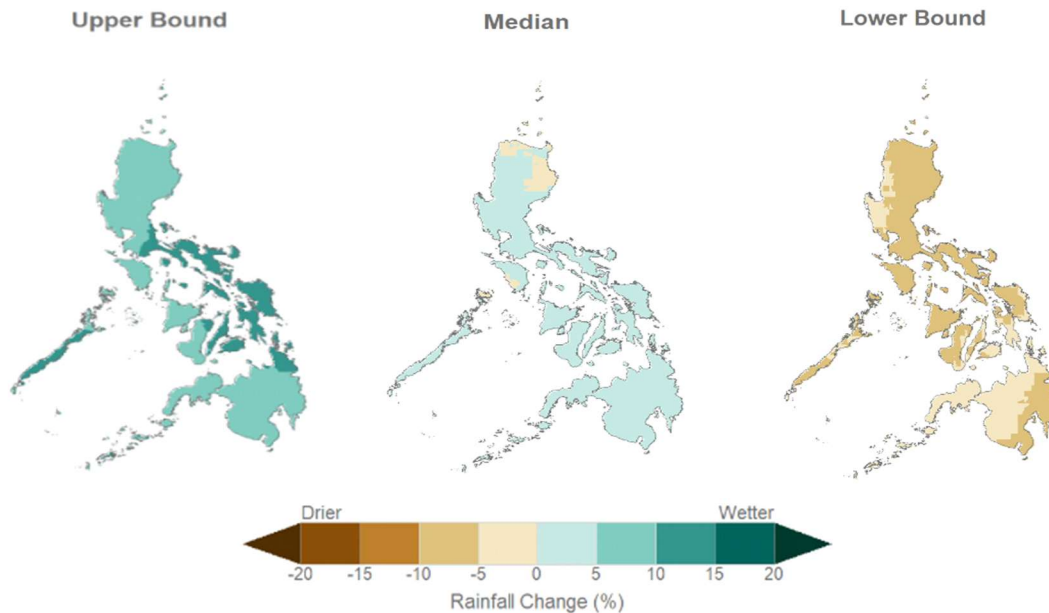


Figure 2.16. Projected Changes in Annual Rainfall from 2021 to 2050 (DOST-PAGASA, 2024)

According to Maskrey & Lavell (2023), uncontrolled and excessive urbanization, such as the NCR and its neighboring provinces, contribute to the aforementioned climate-related threats. As more people opt to live in these areas, land conversion to cater to social, economic, and infrastructure needs is being prioritized; thus, leading to environmental depletion. Furthermore, improper waste management and pollution add to the degradation of the physical environment. This can also lead to higher exposed capital as majority of economic activities are centered in the cities and urban areas (Table 2.1).

Table 2.1. Exposed Capital (in USD) Against Hazards of Localities in 2021 (Pacific Disaster Center, 2021).

Exposed Capital in million USD (2021)										
Localities	Storm Surge	Typhoon Winds	Tsunami	Flooding	Landslide	Earthquake	Liquefaction	Volcanic Eruption	Wildfire	Drought
Ilocos Norte	170.2	3,100	51.9	1,600	108.2	3,000	2,400	NA	353.3	2,900
Ilocos Sur	1,300	3,600	59.3	2,300	217.3	3,500	3,200	NA	92.9	NA
La Union	1,200	4,400	2.4	2,700	332	3,800	3,000	NA	184.2	NA
Pangasinan	1900	14,900	7.9	12,600	166.8	14,700	12,500	26.3	1700	NA
Cagayan	617.7	8,200	163.1	6,400	156	8,000	7,200	49.4	499.1	8,200
Batanes	NA	55.5	1.6	NA	27	NA	NA	19.7	NA	NA
Zambales	782.3	1,500	4.3	912.6	73.4	1,400	1,200	15.6	711.2	NA
Bataan	870.6	1,900	8.9	1,700	72.6	1,800	1,200	6	20	NA
Pampanga	16	5,500	5.8	5,500	25.4	5,500	4,900	74.8	682.8	NA
Bulacan	2,000	13,100	5.2	10,500	27.2	13,100	7,400	39.2	2,900	0.97
NCR	33,700	5.54	434.5	119,600	NA	156,100	74,200	472	NA	NA
Cavite	1,700	3.59	32.2	6,300	101.1	10,300	4,700	57.8	6,800	NA
Batangas	744.7	6,900	6.6	0.3	0.3	6,800	1,200	290.5	416.5	NA
Occidental Mindoro	343.8	1,200	7.6	1,100	129.2	1,100	728.5	0.64	444.9	3.5
Palawan	321	1,100	10.2	1,100	310.1	NA	679	NA	154	1,500
Legend:	High	Medium	Low	NA/No Data						

2.3.3. Mitigating Socioeconomic Vulnerability from Climate-Mediated Environmental Change- Current Actions and Gaps

There were various social, economic, and environmental interconnected challenges discussed above. It showed how climate-related threats can bring huge negative social and economic impacts to various affected localities; thus, a need for mitigation measures.

The NCR and nearby provinces were the center of economic development. The majority of the industries and services were located in these areas. Increasing income and taxes paved the way for investments in information, communication, and technology (D'Acci, 2021) for better predictions on and communication of hazards and disasters. However, insufficient digital literacy (Andaya *et al.*, 2025) hinders the effective delivery of information. Moreover, uncontrolled urbanization led to further environmental degradation. Thus, more frequent and intense disasters result in greater losses since there is little to no vegetation as natural protection against calamities (Maskrey & Lavell, 2023).

Neighboring provinces of the NCR prioritized urban green spaces (Province of Cavite, 2021). However, increasing demand for economic and residential needs due to urbanization led to land conversions. Aside from this, improper waste management may result in pollution and degradation of water resources across the country.

Eco-tourism played a vital role in increasing economic growth yet conserving the natural environment of island provinces and those situated far from the NCR. Ironically, illegal and unsustainable economic practices threaten the biodiversity and natural beauty of these places. Although ordinances such as a mining moratorium (Ticke & Lagare, 2025) are being implemented, these will not be effectively enforced without proper monitoring and evaluation.

2.3.4 Recommended Priority Actions

To strengthen current actions and resolve the challenges, the figure below was provided to better visualize recommended laws and PPAs that can be done within 20 years. This highlights the use of research to come up with baseline data and smart efforts for local communities. For instance, it can include nature-based solutions (NbS) and grassroots initiatives anchored to science, technology, and innovation (STI). Hence, modernization efforts, including infrastructure projects, were aligned with sustainability and local ecological knowledge. Moreover, regular capacitation was proposed across all sectors to ensure that people are knowledgeable and skilled on future development efforts so they can actively participate and have a sense of ownership of the proposed efforts to their communities. These would be feasible through partnerships, network-building, and strong executive-legislative support of the government.

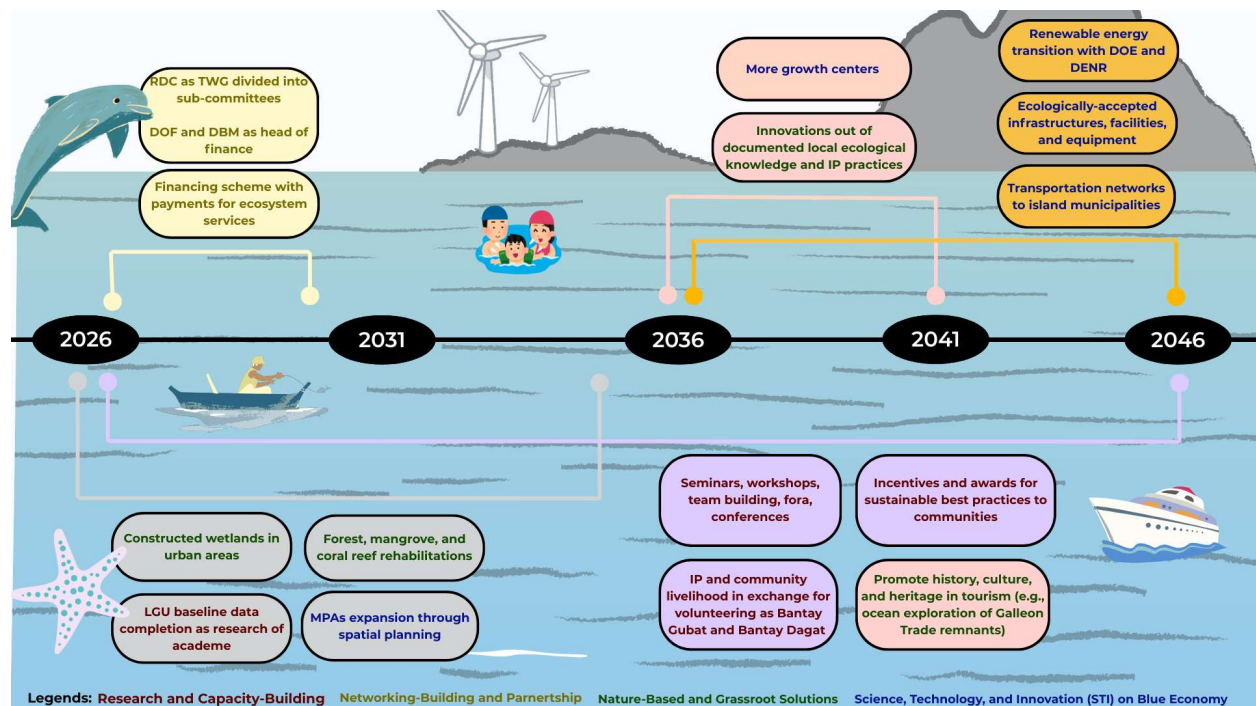


Figure 2.17. Roadmap of Recommended Priority Actions for 2026-2046

2.4 Methodology and Analysis

This chapter covered the coastal provinces along the Philippine Seas in the SCS-LME from Regions I to IV-B of the Philippines (Region I: Ilocos Norte, Ilocos Sur, La Union, Pangasinan; Region II: Cagayan, Batanes; Region III: Zambales, Bataan, Pampanga, Bulacan; NCR; Region IV-A: Cavite, Batangas; Region IV-B: Occidental Mindoro, Palawan). The sub-national unit used in the analyses is at the provincial level considering the ridge-to-reef approach, where economic activities in the upland communities affect the blue economy and vice versa.

There were given socio-economic indicators (Annex I) that should be filled out through provincial data available online. Hence, PSA, PAGASA, provincial websites, and various data searches were conducted from June to August 2025 to fill in the data requirements of the indicators. Tables (Annex II and III) and graphs were created in Google Sheets while digitized maps (Annex IV) were created through the QGIS application. These were used for better visualization of the data. Brief explanations of the figures were provided along with analysis, as supported by several studies.

Glossary

- Biodiversity Hotspot - biogeographic region with high number of classified endemic species, yet significant habitat loss
- Blue Economy - sustainable utilization of ocean resources for livelihood/ job enhancement and economic growth, yet preserving healthy ocean ecosystems, divided into the following sectors:
 - (1) Aquaculture - farming aquatic organisms within open ocean or coastal waters
 - (2) Coastal and Marine Infrastructure - institutional and physical systems that facilitate sustainable utilization of resources for economic purposes while protecting the ecosystem
 - (3) Coastal and Marine Tourism - recreational activities done in marine and coastal zones
 - (4) Deep Sea Mining - industries requiring retrieval of non-living resources below the seafloor
 - (5) Fisheries - capturing wild aquatic biological resources such as plants, shellfish, and fish
 - (6) Marine Biotechnology - developing new and important products out of marine biodiversity
 - (7) Marine Transportation - moving/ transporting people, goods, and services across seas
 - (8) Renewable Marine Energy - clean energy generation from the ocean
- Congestion - state of being crowded, clogged, or full
- Ecosystem Services - benefits that human obtain from the ecosystem, categorized into:
 - (1) Cultural Services - non-material benefits from the environment (e.g., tourism and recreation, education, research, spiritual enhancement)
 - (2) Provisioning Services - tangible products from the environment (e.g., food, water, medicine, fuel)
 - (3) Regulating Services - acquired out of the ability of the environment to regulate ecosystem processes (e.g., water purification, pest and disease control, climate and flood control)
 - (4) Supporting Services - essential support for producing the other services (e.g., soil formation, photosynthesis, nutrient cycling)
- Far-Flung Areas - very distant, remote, or difficult to reach places
- Fertility Rates - a measure of the woman's average number of children over a lifetime
- Geographic Isolation - state where population is physically separated by barriers (e.g., mountains, rivers, oceans) that may limit flow of goods and services
- Global Warming - long-term, yet rapid increase in the average surface temperature of the Earth, mainly caused by unsustainable human activities (e.g., deforestation, burning fossil fuel)
- Grassroot Solutions - community-driven efforts to resolve development problems by using local knowledge, resources, and networks
- Greenhouse Gases - gases in the atmosphere of the Earth with the ability to trap heat coming from the sun
- Human Capital - economic value of people based on education, knowledge, skills, potential, experience, health, and other attributes that may strengthen productivity

- Human Development Index - a key metric to measure human well-being and quality of life using indicators/ elements which include per capita income, education, and life expectancy
- Indigenous Peoples - communities with deep historical and cultural ties with their ancestral lands, possessing unique history, tradition, language, knowledge, and social structures
- Local Ecological Knowledge - deeply-rooted and practical knowledge/ understanding of the local ecosystems, the species, and the environment that communities develop through experience and cultural practices, usually passed down to generations and offer important insights for resource management efforts, conservation, and climate shift adaptation
- Nature-Based Solutions - smart and cost-effective ways of using natural processes/ nature to resolve societal concerns
- Per Capita - Latin term for “per person/ head”
- Poor Families - in the Philippines, as per Republic Act No. 8425, this refers to households with per capita income/ expenses lower than declared per capita national family poverty threshold of Php 13,873 (USD 250) per month for a family composed of 5 members
- Population Density - use to measure the number of people situated per unit of land area to assess their distribution/ crowdedness of a place
- Poverty Incidence - proportion of individuals/ families with income below poverty threshold
- Ridge-to-Reef Approach - holistic way of managing land, water, and marine resources by recognizing their interconnectedness; hence, integrated issues and efforts that should be done from mountain uplands (ridges) to coastal areas/ coral reefs
- Rural Areas - outside cities known for low population density, yet large land area for agriculture and forestry
- Tropical Cyclone - a powerful rotating storm system that forms over warm ocean waters
- Urban Areas - settlement with high population density wherein in the Philippines, as per Republic Act No. 7279, this can refer to localities with population density of at least 500 persons per square kilometer of land

Acronyms

- ASEAN - Association of Southeast Asian Nations
- CALABARZON - Cavite, Laguna, Batangas, Rizal
- CDRA - Climate and Disaster Risk Assessment
- CDP - Comprehensive Development Plan
- CLUP - Comprehensive Land Use Plan
- COVID - Coronavirus Disease
- CSOs - Civil Society Organizations
- DMB - Department of Budget and Management
- DEPDev - Department of Economy, Planning, and Development
- DOF - Department of Finance
- DOH - Department of Health
- DOST - Department of Science and Technology
- FLEMMS - Functional Literacy, Education, and Mass Media Survey
- GHG - Greenhouse Gases
- HDI - Human Development Index
- HDNFI - Human Development Network Foundation Incorporated
- ICM - Integrated Coastal Management
- IEC - Information, Communication, and Education
- LDIP - Local Development Investment Program
- NCR - National Capital Region
- NEDA - National Economic and Development Authority
- NLUA - National Land Use Act

- PAGASA - Philippine Atmospheric, Geophysical and Astronomical Services Administration
- PPAs - Programs, projects, and activities
- PSA - Philippine Statistics Authority
- QGIS - Quantum Geographic Information System
- RDC - Regional Development Council
- SCS-LME - South China Sea Large Marine Ecosystem
- SDGs - Sustainable Development Goals
- STI - Science, Technology, and Innovation
- TC - Tropical Cyclone
- UNDP - United Nations Development Programme

Declaration of competing interest

The authors declare no conflicts of interest influencing the design, conduct, or interpretation of this work.

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Chapter 2 Annexes

Annex 2.A. List of Indicators

Table 2.A.1. List of Demographic Indicators

SC1 Demographics	Components
SE1-1. Subnational Population	Number of Female Households
	Number of Male Households
	Total Households
	Total Population
	Growth Rate
SE1-2. Areas of Subnational First Level Administrative Region	Total Land Area (sq km)
SE1-3. Subnational Populations as % of National Population	% to Philippine Population
SE1-4. Subnational Region Areas as % of National Area	% to Philippines' Total Land Area (sq km)
SE1-5. Annual Population Changes	% Annual Change in the Population
SE1-6. Population Densities	Population Density (people/ sq km)
SE1-10 Urbanization Rate	
SE1-11 Built Up Surface	Total Floor Area of Construction (sq km)

Table 2.A.2. List of Human Well-Being Indicators

SC2 Human Well-being	Components
SE2.1 Poverty	Poverty Incidence Among Families (%)
SE2.2 Contemporary Human Development Index HDI	Level of Literacy (Illiterate, Low Literate, Basic Literate)
	HDI Value and Classification

Table 2.A.3. List of Blue Economy Indicators

SC3 Blue Economy	Components
SE3.1. Subnational Regional GDP by Economic Sector (Agriculture, Manufacturing, Services)	Agriculture, Forestry, and Fisheries Value Added at Current Price
	Manufacturing
	Manufacturing Value Added at Current Price
	Mining and Quarrying
	Electricity, Steam, Water, and Waste Management
	Construction
	Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles
	Services Value Added at Current Price
	Transportation and Storage
	Accommodation and Food Service Activities
Information and Communication	
Financial and Insurance	

SC3 Blue Economy	Components
	Activities
	Real Estate and Ownership of Dwellings
	Professional and Business Services
	Public Administration & Defense and Compulsory Social Activities
	Education
	Human Health and Social Work Activities
	Other Services

Table 2.A.4. List of Climate-Related Threats Indicators

SE4 Climate-Related Threats	Components
SE4-1. Number of Tropical Cyclones and Typhoons	
SE4-2. Number of Deaths Because of Tropical Cyclones and Typhoons	Storm Surge
	Typhoon Winds
	Tsunami
	Flooding
	Landslide
SE4-3 Possible Total Damage Due to Hazards and Disasters	Earthquake
	Liquefaction
	Volcanic Eruption
	Wildfire
	Drought
	Other risks (epidemics, conflicts, etc)

Annex 2.B. Socioeconomics Threats Database

Table 2.B.1. Population of Localities from 1995 to 2020 (Philippine Statistics Authority, 2023).

Localities	Historical Data of Population					
	1995	2000	2007	2010	2015	2020
Ilocos Norte	482,651	514,241	547,284	568,017	593,081	609,588
Ilocos Sur	545,385	594,206	633,138	658,587	689,668	706,009
La Union	597,442	657,945	720,972	741,906	786,653	822,352
Pangasinan	2,178,412	2,434,086	2,645,395	2,779,862	2,956,726	3,163,190
Cagayan	895,050	993,580	1,072,571	1,124,773	1,199,320	1,268,603
Batanes	14,180	16,467	15,974	16,604	17,246	18,831
Zambales	569,266	627,802	720,355	755,621	823,888	909,932
Bataan	491,459	557,659	662,153	687,482	760,650	853,373
Pampanga	1,635,767	1,882,730	2,229,349	2,340,355	2,609,744	2,900,637
Bulacan	1,784,441	2,234,088	2,822,216	2,924,433	3,292,071	3,708,890
NCR	9,454,040	9,932,560	11,547,959	11,855,975	12,877,253	13,484,462
Cavite	1,610,324	2,063,161	2,856,765	3,090,691	3,678,301	4,344,829
Batangas	1,658,567	1,905,348	2,245,869	2,377,395	2,694,335	2,908,494
Occidental Mindoro	339,605	380,250	421,952	452,971	487,414	525,354
Palawan	640,486	755,412	892,660	994,340	1,104,585	1,246,673

Table 2.B.2. Projected Population of Localities from 2025 to 2050

Localities	Projected Populations					
	2025	2030	2035	2040	2045	2050
Ilocos Norte	612,952	616,334	619,735	623,154	626,593	630,050
Ilocos Sur	709,330	712,666	716,018	719,386	722,769	726,169
La Union	829,711	837,135	844,625	852,182	859,807	867,500
Pangasinan	3,206,416	3,250,233	3,294,649	3,339,671	3,385,309	3,431,570
Cagayan	1,282,998	1,297,556	1,312,279	1,327,169	1,342,228	1,357,458
Batanes	19,168	19,510	19,859	20,214	20,575	20,943
Zambales	928,338	947,116	966,274	985,819	1,005,759	1,026,103
Bataan	873,418	893,934	914,932	936,422	958,418	980,930
Pampanga	2,963,128	3,026,966	3,092,178	3,158,796	3,226,849	3,296,367
Bulacan	3,799,253	3,891,817	3,986,636	4,083,765	4,183,261	4,285,180
NCR	13,609,761	13,736,224	13,863,862	13,992,685	14,122,706	14,253,935
Cavite	4,493,987	4,648,265	4,807,840	4,972,893	5,143,611	5,320,191
Batangas	2,953,604	2,999,414	3,045,934	3,093,176	3,141,150	3,189,868
Occidental Mindoro	533,338	541,443	549,670	558,023	566,503	575,112
Palawan	1,277,514	1,309,117	1,341,503	1,374,689	1,408,696	1,443,545

Table 2.B.3. Growth Rate of Localities from 1995 to 2020

Localities	Historical Data of Growth Rate					Annual Growth Rate
	1995-2000	2000-2007	2007-2010	2010-2015	2015-2020	
Ilocos Norte	1.276	0.894	1.247	0.867	0.551	0.110
Ilocos Sur	1.729	0.911	1.322	0.927	0.469	0.094
La Union	1.948	1.315	0.959	1.178	0.892	0.178
Pangasinan	2.244	1.196	1.666	1.241	1.359	0.272
Cagayan	2.111	1.099	1.597	1.292	1.130	0.226
Batanes	3.036	-0.433	1.298	0.762	1.774	0.355
Zambales	1.977	1.984	1.606	1.745	2.007	0.401
Bataan	2.560	2.484	1.259	2.043	2.327	0.465
Pampanga	2.852	2.443	1.633	2.203	2.136	0.427
Bulacan	4.597	3.395	1.193	2.397	2.413	0.483
NCR	0.992	2.176	0.881	1.666	0.926	0.185
Cavite	5.081	4.759	2.658	3.542	3.387	0.677
Batangas	2.813	2.377	1.915	2.535	1.541	0.308
Occidental Mindoro	2.287	1.498	2.393	1.477	1.510	0.302
Palawan	3.356	2.414	3.661	2.125	2.450	0.490

Table 2.B.4. Population Density of Localities from 1995 to 2020

Localities	Total Land Area (sq km)	Population Density (people/ sq km)					
		1995	2000	2007	2010	2015	2020
Ilocos Norte	3,418.75	142	151	161	167	174	179
Ilocos Sur	2,596.00	211	229	244	254	266	272
La Union	1,499.28	399	439	481	495	525	549
Pangasinan	5,450.59	400	447	486	511	543	581
Cagayan	9,398.07	96	106	115	120	128	135
Batanes	203.22	70	82	79	82	85	93
Zambales	3,815.35	150	165	189	199	216	239
Bataan	1,372.98	358	407	483	501	555	622
Pampanga	2,064.59	793	912	1,080	1,134	1,265	1,405
Bulacan	2,783.69	642	803	1,014	1,051	1,183	1,333
NCR	619.54	15,260	16,033	18,640	19,137	20,786	21,766
Cavite	1,526.28	1,056	1,352	1,872	2,025	2,410	2,847
Batangas	3,115.05	533	612	721	764	865	934
Occidental Mindoro	5,851.09	59	65	73	78	84	90
Palawan	17,030.75	38	45	53	59	65	74

Table 2.B.5. Projected Population Density of Localities from 2025 to 2050

Localities	Projected Population Density (people/sq km)					
	2025	2030	2035	2040	2045	2050
Ilocos Norte	180	181	182	183	184	185
Ilocos Sur	274	275	276	278	279	280
La Union	554	559	564	569	574	579
Pangasinan	589	597	605	613	622	630
Cagayan	137	139	140	142	143	145
Batanes	95	97	98	100	102	104
Zambales	244	249	254	259	264	269
Bataan	637	652	667	683	699	715
Pampanga	1436	1467	1498	1530	1563	1597
Bulacan	1365	1399	1433	1468	1503	1540
NCR	21968	22172	22378	22586	22796	23008
Cavite	2945	3046	3151	3259	3371	3486
Batangas	949	963	978	993	1009	1025
Occidental Mindoro	92	93	94	96	97	99
Palawan	76	77	79	81	83	85

Table 2.B.6. Localities' Poverty Incidence Among Families from 2006 to 2023 (Sources: National Statistical Coordination Board, 2013; Philippine Statistics Authority, 2018, 2021, 2023; Siosion, 2022).

Localities	Poverty Incidence Among Families (%)						
	2006	2009	2012	2015	2018	2021	2023
Ilocos Norte	13.7	11.1	8.4	5.2	3.1	1.7	0.3
Ilocos Sur	16.4	13.4	13.7	10.8	5.5	11.5	5.2
La Union	20.8	22.4	15.3	13.5	2.9	6.6	6.3
Pangasinan	21.8	17.2	14.9	16.9	9.3	13.9	11.4
Cagayan	25.1	22.5	15.2	14.0	12.5	7.3	5.7
Batanes	14.3	16.7	18.2	10.0	6.5	2.6	3.3
Zambales	18.6	11.9	12.1	12.3	10.9	17.7	11.8
Bataan	6.2	5.9	4.5	0.8	5.8	9.0	6.6
Pampanga	2.0	4.9	5.4	2.7	2.1	2.9	1.0
Bulacan	4.9	4.6	5.4	3.1	3.5	8.3	6.0
NCR	2.9	2.4	2.6	2.8	1.4	2.2	1.1
Cavite	1.2	2.2	2.6	6.1	3.7	7.1	4.3
Batangas	10.9	12.6	14.7	17.4	8.6	4.3	4.9
Occidental Mindoro	33.5	25.0	29.8	30.5	16.1	23.0	20.6
Palawan	28.2	25.3	20.5	12.6	8.2	9.4	15.8

Table 2.B.7. HDI of Localities from 2006 to 2019 (Philippine Statistics Authority, 2020; 2023)

Localities	HDI				
	2006	2009	2012	2015	2019
Ilocos Norte	0.638	0.653	0.745	0.735	0.820
Ilocos Sur	0.562	0.603	0.682	0.683	0.700
La Union	0.641	0.669	0.695	0.722	0.760
Pangasinan	0.535	0.601	0.596	0.643	0.650
Cagayan	0.584	0.623	0.627	0.671	0.680
Batanes	0.667	0.698	0.535	0.758	0.790
Zambales	0.583	0.596	0.534	0.652	0.690
Bataan	0.673	0.696	0.705	0.793	0.750
Pampanga	0.716	0.667	0.726	0.765	0.760
Bulacan	0.714	0.728	0.713	0.757	0.760
NCR	0.801	0.818	0.817	0.849	0.850
Cavite	0.74	0.726	0.733	0.748	0.780
Batangas	0.642	0.661	0.675	0.731	0.740
Occidental Mindoro	0.492	0.568	0.554	0.607	0.610
Palawan	0.505	0.509	0.603	0.699	0.660

Table 2.B.8. HDI Indicators of Localities in 2015 (Human Development Network Foundation Inc., 2021).

Localities	HDI Indicators (2015)			
	Life Expectancy at Birth (Years)	Mean Years of Schooling	Expected Years of Schooling	Per Capita Income (US 2011 PPP \$)
Ilocos Norte	70.0	9.9	12.8	2,956
Ilocos Sur	71.2	9.4	13.6	2,729
La Union	68.5	9.9	13.0	2,663
Pangasinan	69.1	9.8	12.2	2,307
Cagayan	70.6	8.9	12.9	2,570
Batanes	71.2	11.2	7.0	5,226
Zambales	70.2	9.6	13.1	3,007
Bataan	69.9	10.0	12.3	4,276
Pampanga	70.8	9.9	12.6	3,520
Bulacan	70.6	9.7	12.6	3,397
NCR	73.3	11.1	13.1	4,590
Cavite	70.7	10.4	12.3	3,702
Batangas	70.2	9.7	12.6	3,167
Occidental Mindoro	68.4	8.4	12.5	2,151

Table 2.B.9. Value Added at Current Prices (2023) of Economic Sectors in Different Localities (Philippine Statistics Authority, 2025).

Localities	Agriculture, Forestry, and Fisheries Value Added at Current Price (2023)	Manufacturing Value Added at Current Price (2023)				Services Value Added at Current Price (2023)			
		Manufacturing	Electricity, Steam, Water, and Waste Management	Construction	Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles	Transportation and Storage	Accomm. and Food Service Activities	Info and Comm	Financial and Insurance Activities
Ilocos Norte	21,230,803.15	6,705,006.06	13,815,692.20	17,594,635.69	19,494,889.67	5,092,558.54	3,888,511.57	3,937,442.40	5,059,036.50
Ilocos Sur	19,908,982.14	2,589,322.65	6,670,539.31	21,437,368.67	22,581,851.19	2,749,742.00	4,090,437.27	3,523,167.48	6,122,531.06
La Union	13,923,341.21	10,497,288.41	12,695,632.53	28,873,379.98	27,708,155.48	4,348,522.55	3,558,868.29	5,488,280.13	4,978,502.23
Pangasinan	79,233,747.09	52,994,305.59	29,868,480.97	50,059,143.56	72,778,393.88	11,761,859.36	13,499,490.42	15,234,596.85	18,528,561.84
Cagayan	48,713,791.21	13,734,292.34	4,456,319.35	31,418,103.56	24,203,139.63	10,163,254.01	4,058,420.78	6,879,939.20	5,757,956.67
Batanes	388,306.85	362,878.45	187,707.92	1,363,816.27	433,947.60	918,354.90	530,055.12	231,273.83	163,628.79
Zambales	14,403,770.41	18,505,379.74	11,139,062.39	35,180,023.88	24,043,529.74	12,277,856.03	4,713,759.57	8,703,805.51	7,079,141.67
Bataan	10,482,070.37	139,343,421.81	22,338,083.00	35,709,660.37	27,497,285.75	10,393,384.46	6,199,633.81	8,898,228.28	8,520,159.81
Pampanga	87,300,435.82	208,366,809.20	21,328,513.57	69,747,068.35	82,859,202.92	35,269,619.41	25,292,173.86	32,707,480.17	34,531,757.55
Bulacan	45,872,149.37	187,864,140.40	20,974,550.68	130,434,408.01	85,536,073.02	28,630,983.44	16,757,016.83	35,557,278.92	24,002,277.22
NCR	622,442.86	859,803,102.69	113,054,723.58	322,595,779.31	1,713,958,489.10	187,277,601.61	97,612,255.57	171,873,049.58	1,532,893,897.77
Cavite	19,938,327.86	341,712,048.97	12,031,534.76	34,855,654.52	136,021,585.01	38,668,678.61	19,713,309.56	43,771,790.94	52,594,585.24
Batangas	69,499,766.61	270,832,950.71	76,987,567.70	30,934,510.15	63,512,695.17	21,725,547.65	11,476,194.74	26,063,854.86	37,325,921.65
Occidental Mindoro	17,279,740.28	3,062,139.79	4,985,167.97	7,236,669.00	8,556,689.45	2,916,868.78	535,876.12	1,757,574.61	4,321,428.18
Palawan	37,960,025.22	23,847,718.32	8,782,228.08	10,663,562.19	23,960,120.56	18,774,591.29	9,636,136.53	8,636,996.02	9,233,045.87

Table 2.B.9. (Continuation...)

Localities	Agriculture, Forestry, and Fisheries Value Added at Current Price (2023)	Manufacturing Value Added at Current Price (2023)				Services Value Added at Current Price (2023)				
		Manufacturing	Electricity, Steam, Water, and Waste Management	Construction	Real Estate and Ownership of Dwellings	Professional and Business Services	Public Administration and Defense, Compulsory Social Activities	Education	Human Health and Social Work Activities	Other Services
Ilocos Norte	21,230,803.15	6,705,006.06	13,815,692.20	17,594,635.69	6,268,275.43	1,600,532.54	3,652,679.19	5,966,938.22	2,343,230.21	1,791,597.10
Ilocos Sur	19,908,982.14	2,589,322.65	6,670,539.31	21,437,368.67	7,170,640.80	1,331,905.04	4,820,104.78	6,745,135.13	4,037,544.82	1,867,755.23
La Union	13,923,341.21	10,497,288.41	12,695,632.53	28,873,379.98	8,154,768.96	2,271,367.10	7,567,375.30	7,115,248.34	3,252,021.55	3,828,044.74
Pangasinan	79,233,747.09	52,994,305.59	29,868,480.97	50,059,143.56	25,410,388.56	7,287,291.03	11,212,538.83	26,486,419.20	10,416,624.19	9,166,889.95
Cagayan	48,713,791.21	13,734,292.34	4,456,319.35	31,418,103.56	8,373,054.61	1,638,153.31	6,035,458.75	11,223,377.67	4,766,774.47	1,114,762.83
Batanes	388,306.85	362,878.45	187,707.92	1,363,816.27	166,445.81	139,574.90	504,240.02	454,308.62	217,044.43	79,417.11
Zambales	14,403,770.41	18,505,379.74	11,139,062.39	35,180,023.88	10,008,137.47	3,449,930.60	5,267,065.23	7,497,519.80	2,038,756.23	7,343,086.38

Localities	Agriculture, Forestry, and Fisheries Value Added at Current Price (2023)	Manufacturing Value Added at Current Price (2023)			Services Value Added at Current Price (2023)					
		Manufacturing	Electricity, Steam, Water, and Waste Management	Construction	Real Estate and Ownership of Dwellings	Professional and Business Services	Public Administration and Defense, Compulsory Social Activities	Education	Human Health and Social Work Activities	Other Services
Bataan	10,482,070.37	139,343,421.81	22,338,083.00	35,709,660.37	10,943,214.77	11,716,342.63	4,218,125.23	7,066,099.87	2,881,916.52	8,465,314.64
Pampanga	87,300,435.82	208,366,809.20	21,328,513.57	69,747,068.35	51,610,669.55	75,208,071.91	16,452,313.19	22,235,871.68	13,481,115.48	21,970,104.09
Bulacan	45,872,149.37	187,864,140.40	20,974,550.68	130,434,408.01	37,406,319.91	33,534,540.89	9,201,839.34	26,209,327.78	10,074,032.40	20,003,525.91
NCR	622,442.86	859,803,102.69	113,054,723.58	322,595,779.31	471,552,062.16	978,264,419.87	652,711,226.25	159,239,357.20	146,838,075.65	163,596,339.82
Cavite	19,938,327.86	341,712,048.97	12,031,534.76	34,855,654.52	57,270,963.89	25,234,834.93	18,850,742.84	36,453,103.98	12,012,736.11	17,770,292.93
Batangas	69,499,766.61	270,832,950.71	76,987,567.70	30,934,510.15	45,338,693.03	12,325,537.50	19,653,942.14	26,756,167.00	8,484,973.61	11,386,609.86
Occidental Mindoro	17,279,740.28	3,062,139.79	4,985,167.97	7,236,669.00	1,473,555.68	906,637.83	2,549,677.02	4,123,143.74	803,297.13	2,242,168.92
Palawan	37,960,025.22	23,847,718.32	8,782,228.08	10,663,562.19	6,838,719.98	2,338,897.77	7,292,329.34	9,628,384.96	3,272,547.36	9,172,044.35

Table 2.B.10. Value Added at Current Prices of Agriculture, Forestry, and Fisheries in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025)

Localities	Agriculture, Forestry, and Fisheries Value Added at Current Price (2023)					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	17,107,229.24	16,360,223.43	18,772,234.93	19,887,559.33	19,372,172.25	21,230,803.15
Ilocos Sur	14,118,038.90	14,117,404.29	15,423,318.90	16,797,339.75	18,314,873.71	19,908,982.14
La Union	11,301,327.27	11,026,759.74	11,796,742.01	11,031,735.10	13,453,174.60	13,923,341.21
Pangasinan	67,200,148.80	62,910,244.03	65,760,438.42	68,181,053.57	73,032,458.73	79,233,747.09
Cagayan	33,914,777.20	32,384,298.86	34,583,516.41	40,753,256.75	43,669,858.74	48,713,791.21
Batanes	232,490.48	255,762.70	237,735.30	255,139.87	282,496.88	388,306.85
Zambales	13,594,894.73	11,872,112.95	14,326,538.17	14,996,747.26	15,026,079.42	14,403,770.41
Bataan	13,157,228.09	12,107,583.87	11,230,130.12	11,516,476.77	10,700,379.93	10,482,070.37
Pampanga	56,404,652.18	51,029,311.32	56,218,697.28	70,073,070.21	71,807,998.57	87,300,435.82
Bulacan	50,857,107.64	48,194,297.66	45,530,244.57	36,756,659.70	43,843,776.43	45,872,149.37
NCR	397,869.79	442,597.10	450,941.54	503,378.47	560,698.27	622,442.86
Cavite	17,307,658.08	16,420,834.50	16,657,912.24	17,697,988.80	17,925,715.31	19,938,327.86
Batangas	50,262,883.88	54,782,090.46	57,224,160.88	58,842,851.81	64,522,404.68	69,499,766.61
Occidental Mindoro	13,514,546.12	11,864,155.86	11,600,903.83	14,719,199.66	15,644,945.65	17,279,740.28
Palawan	30,963,790.46	31,401,751.07	31,618,704.24	32,691,904.36	34,878,803.01	37,960,025.22

Table 2.B.11. Value Added at Current Prices of Manufacturing in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025)

Localities	Manufacturing at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	4,905,840.39	5,665,943.19	5,426,458.07	5,849,697.56	6,461,760.47	6,705,006.06
Ilocos Sur	1,916,225.91	2,171,712.95	2,047,827.66	2,168,092.78	2,384,008.50	2,589,322.65
La Union	8,077,289.32	9,175,936.67	8,672,818.97	9,536,874.40	10,308,489.77	10,497,288.41
Pangasinan	38,156,770.71	42,664,638.89	40,814,767.88	45,213,454.29	49,285,363.70	52,994,305.59
Cagayan	11,912,932.41	12,594,404.18	10,762,603.28	11,541,152.56	12,447,176.71	13,734,292.34
Batanes	297,232.98	315,909.62	274,874.10	295,359.96	317,055.84	362,878.45
Zambales	18,098,939.40	19,475,969.71	13,142,626.96	15,267,037.83	17,421,269.49	18,505,379.74
Bataan	119,630,166.47	127,341,553.70	89,728,153.40	109,132,521.82	130,000,078.91	139,343,421.81
Pampanga	180,020,128.65	194,218,190.02	143,252,417.37	172,481,046.69	195,710,075.68	208,366,809.20
Bulacan	177,718,684.63	189,217,677.30	137,156,293.90	163,725,998.03	178,257,192.64	187,864,140.40
NCR	789,421,475.80	822,544,373.27	759,278,157.77	770,700,168.34	835,168,015.28	859,803,102.69
Cavite	308,127,756.35	311,778,338.25	235,988,928.06	277,843,154.22	316,475,229.10	341,712,048.97
Batangas	233,435,892.91	258,636,718.07	190,677,061.07	229,413,205.78	263,922,067.41	270,832,950.71
Occidental Mindoro	3,295,136.43	3,019,780.99	2,837,865.68	2,930,793.10	3,143,810.99	3,062,139.79
Palawan	21,565,186.42	21,445,968.14	19,987,716.73	21,480,411.61	23,975,368.40	23,847,718.32

Table 2.B.12. Value Added at Current Prices of Mining and Quarrying in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Mining and Quarrying at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	148,658.76	174,642.72	203,359.35	214,177.25	265,870.54	280,128.59
Ilocos Sur	58,928.09	77,361.05	72,387.97	90,328.01	100,534.61	110,301.55
La Union	350,446.84	413,636.65	422,803.92	483,434.11	520,404.85	528,360.24
Pangasinan	677,335.67	781,033.85	816,238.45	866,584.31	1,011,915.56	1,080,968.07
Cagayan	704,232.05	774,450.29	822,546.23	984,464.74	1,036,143.03	1,072,590.13
Batanes	1,819.77	2,098.10	2,470.89	2,912.13	3,141.97	3,334.83
Zambales	968,543.99	504,572.97	596,086.70	2,367,069.16	5,225,750.39	6,217,029.07
Bataan	17,929.75	17,745.77	11,516.81	13,977.02	16,965.44	22,177.93
Pampanga	2,885,185.63	2,634,725.09	1,867,008.58	2,366,311.27	3,386,703.28	4,447,310.03
Bulacan	2,745,570.71	2,750,644.18	1,975,736.03	2,193,759.07	3,201,337.79	4,194,324.36
NCR	473,494.13	435,845.60	375,384.05	396,643.82	430,591.79	454,249.62
Cavite	77,847.32	83,912.66	68,798.52	88,822.62	106,177.77	110,811.40
Batangas	458,579.73	564,579.97	524,204.30	594,724.47	710,529.84	758,052.66
Occidental Mindoro	86,806.76	99,400.82	98,935.22	128,805.06	165,006.60	166,043.33

Localities	Mining and Quarrying at Current Prices					
	2018	2019	2020	2021	2022	2023
Palawan	38,806,465.68	32,812,741.47	22,483,489.45	35,552,679.49	55,453,156.09	26,286,054.35

Table 2.B.13. Value Added at Current Prices of Electricity, Steam, Water, and Waste Management in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Electricity, Steam, Water, and Waste Management at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	8,517,391.18	9,352,974.78	9,208,364.23	9,340,725.76	12,165,575.63	13,815,692.20
Ilocos Sur	4,276,370.89	4,758,834.39	4,585,211.99	4,673,453.00	6,048,600.49	6,670,539.31
La Union	8,162,996.74	9,031,312.79	8,582,659.06	8,762,373.28	11,328,840.53	12,695,632.53
Pangasinan	19,172,510.91	21,510,395.67	21,090,454.13	21,522,411.82	26,946,724.90	29,868,480.97
Cagayan	2,646,829.69	3,077,975.64	3,187,686.52	3,433,220.60	4,215,826.32	4,456,319.35
Batanes	118,524.13	141,757.42	141,653.70	149,485.15	175,624.76	187,707.92
Zambales	5,706,190.68	6,541,164.75	6,622,745.67	7,115,885.24	9,346,684.89	11,139,062.39
Bataan	11,583,206.87	13,374,793.34	13,415,285.17	15,002,158.76	19,410,325.37	22,338,083.00
Pampanga	11,550,330.19	13,005,488.92	13,012,009.64	14,303,476.13	17,924,043.29	21,328,513.57
Bulacan	11,402,845.89	12,997,494.82	13,226,241.20	13,969,130.11	17,545,104.62	20,974,550.68
NCR	89,675,048.03	99,362,853.48	90,302,412.72	92,298,621.28	97,268,593.15	113,054,723.58
Cavite	8,143,152.98	8,805,092.84	9,208,441.60	9,826,089.56	10,251,213.92	12,031,534.76
Batangas	49,769,816.84	53,357,519.73	52,578,164.08	58,577,104.09	67,159,198.21	76,987,567.70
Occidental Mindoro	3,143,033.15	3,423,458.65	3,346,202.80	3,653,716.59	4,157,754.63	4,985,167.97
Palawan	5,275,124.83	5,608,408.84	5,970,171.69	6,245,428.48	7,372,612.56	8,782,228.08

Table 2.B.14. Value Added at Current Prices of Construction in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025)

Localities	Construction at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	12,051,226.46	14,484,216.58	11,793,308.34	12,883,535.80	15,701,428.09	17,594,635.69
Ilocos Sur	13,781,143.07	16,919,959.70	12,863,374.57	16,983,294.60	18,873,343.03	21,437,368.67
La Union	19,315,241.12	21,597,641.08	19,732,347.43	23,872,617.62	25,246,571.03	28,873,379.98
Pangasinan	32,569,239.61	35,083,580.13	33,532,826.71	37,686,576.07	43,232,386.84	50,059,143.56
Cagayan	28,606,013.08	29,279,376.69	19,936,214.46	20,701,270.89	25,369,791.40	31,418,103.56
Batanes	679,353.47	857,732.03	756,530.79	967,713.50	1,138,998.81	1,363,816.27
Zambales	18,541,204.01	23,754,378.65	19,704,800.26	23,910,504.29	31,508,709.25	35,180,023.88
Bataan	34,975,011.78	38,182,005.49	24,269,867.88	26,717,031.45	31,381,696.09	35,709,660.37
Pampanga	45,736,631.57	50,150,075.14	38,061,676.22	47,771,903.46	60,923,503.50	69,747,068.35

Localities	Construction at Current Prices					
	2018	2019	2020	2021	2022	2023
Bulacan	93,150,759.44	109,347,229.81	80,448,630.85	80,626,989.16	100,299,980.09	115,137,448.94
NCR	257,110,627.68	306,290,371.07	246,094,017.67	271,074,220.55	304,430,580.02	322,595,779.31
Cavite	28,785,798.71	31,892,439.62	18,941,879.32	25,872,612.68	30,404,868.82	34,855,654.52
Batangas	21,103,834.53	23,191,791.74	18,671,475.35	21,834,242.12	25,566,294.47	30,934,510.15
Occidental Mindoro	6,012,873.41	5,095,388.37	4,592,891.77	5,378,573.32	6,365,830.72	7,236,669.00
Palawan	7,797,908.13	7,408,751.45	6,548,496.83	7,372,322.19	9,090,542.84	10,663,562.19

Table 2.B.15. Value Added at Current Prices of Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	12,177,826.07	13,669,805.23	13,549,233.88	14,462,271.11	16,789,914.86	19,494,889.67
Ilocos Sur	15,010,575.47	16,613,468.39	16,233,772.40	17,298,050.74	20,201,782.33	22,581,851.19
La Union	18,642,523.35	21,233,722.15	21,026,929.39	22,093,609.03	24,446,882.28	27,708,155.48
Pangasinan	50,068,420.03	55,948,887.00	54,578,310.61	56,668,485.35	65,114,635.87	72,778,393.88
Cagayan	16,664,559.90	17,806,453.10	17,434,626.04	18,555,121.52	21,651,343.35	24,203,139.63
Batanes	237,461.14	266,068.07	289,295.52	307,720.77	394,498.13	433,947.60
Zambales	18,885,112.31	20,365,866.68	18,653,597.82	18,645,310.39	21,811,253.26	24,043,529.74
Bataan	19,720,608.37	21,805,129.55	21,347,879.81	22,451,252.46	24,827,330.59	27,497,285.75
Pampanga	60,011,819.73	66,990,670.24	63,448,656.05	65,956,608.06	75,032,984.62	82,859,202.92
Bulacan	64,316,699.12	68,815,190.65	67,275,597.69	69,072,669.29	76,931,034.70	85,536,073.02
NCR	1,309,125,634.32	1,422,206,846.53	1,301,144,789.75	1,382,042,733.04	1,552,955,566.27	1,713,958,489.10
Cavite	102,432,986.42	110,042,044.95	102,480,338.68	106,288,687.02	119,918,456.76	136,021,585.01
Batangas	44,560,128.25	47,555,954.57	44,020,781.16	46,241,589.04	55,981,664.43	63,512,695.17
Occidental Mindoro	5,558,088.20	6,258,928.60	6,474,802.99	6,631,886.64	7,547,208.95	8,556,689.45
Palawan	14,907,550.31	17,547,464.14	17,705,119.15	18,060,829.50	21,335,229.82	23,960,120.56

Table 2.B.16. Value Added at Current Prices of Transportation and Storage in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025)

Localities	Transportation and Storage at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	4,531,737.73	4,401,783.36	2,186,255.79	2,045,679.36	4,254,381.18	5,092,558.54
Ilocos Sur	1,896,192.04	1,878,400.58	1,366,459.12	1,334,385.51	1,695,504.64	2,749,742.00
La Union	3,381,256.78	3,368,697.84	2,429,877.49	2,529,985.20	3,351,347.86	4,348,522.55
Pangasinan	10,654,543.86	11,260,687.97	8,258,539.27	8,567,903.80	10,671,811.21	11,761,859.36

Localities	Transportation and Storage at Current Prices					
	2018	2019	2020	2021	2022	2023
Cagayan	9,870,461.20	9,728,699.98	5,964,575.74	6,270,166.37	8,885,072.21	10,163,254.01
Batanes	949,685.96	915,723.98	457,508.42	373,794.33	570,515.53	918,354.90
Zambales	8,497,005.65	8,750,725.25	7,470,914.06	7,998,758.43	9,605,143.14	12,277,856.03
Bataan	7,158,689.51	7,433,842.22	6,514,759.30	7,211,344.64	8,549,758.12	10,393,384.46
Pampanga	25,864,336.69	27,857,456.98	21,098,517.33	23,326,842.25	29,207,811.98	35,269,619.41
Bulacan	19,580,039.38	20,375,321.85	18,267,623.60	20,440,662.26	23,884,630.61	28,630,983.44
NCR	149,376,555.87	151,711,031.24	104,217,761.01	112,514,501.25	160,215,981.57	187,277,601.61
Cavite	25,668,470.70	27,361,689.92	25,156,343.13	28,728,180.38	34,280,870.99	38,668,678.61
Batangas	14,699,354.31	16,372,360.79	14,137,133.48	15,932,168.75	19,035,790.78	21,725,547.65
Occidental Mindoro	2,474,850.27	2,807,760.01	2,278,616.78	2,210,098.74	2,624,442.66	2,916,868.78
Palawan	12,931,003.00	14,033,315.38	9,750,546.66	9,406,742.75	16,429,237.81	18,774,591.29

Table 2.B.17. Value Added at Current Prices of Accommodation and Food Service Activities in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Accommodation and Food Service Activities at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	2,807,865.08	3,036,163.37	1,879,424.08	2,275,801.60	3,026,529.68	3,888,511.57
Ilocos Sur	2,684,375.26	2,932,049.26	1,805,394.83	2,131,555.95	3,255,630.37	4,090,437.27
La Union	3,061,295.28	3,282,503.87	1,617,532.19	1,910,777.00	2,961,377.87	3,558,868.29
Pangasinan	10,834,361.44	11,521,048.75	6,498,915.18	7,583,989.88	10,951,506.73	13,499,490.42
Cagayan	2,864,828.35	3,171,678.24	1,677,314.13	2,120,675.50	3,328,766.02	4,058,420.78
Batanes	339,194.70	405,402.38	252,591.71	301,174.08	407,012.98	530,055.12
Zambales	3,617,413.96	3,762,931.06	2,205,631.14	2,489,051.42	3,534,185.69	4,713,759.57
Bataan	4,545,102.39	4,926,209.24	3,023,493.85	3,517,838.43	4,849,182.88	6,199,633.81
Pampanga	19,314,063.85	20,059,329.81	11,338,120.97	13,394,467.58	18,972,731.90	25,292,173.86
Bulacan	12,649,973.54	13,622,541.63	7,386,427.79	9,023,867.13	12,114,208.45	16,757,016.83
NCR	110,538,628.59	113,000,796.23	58,412,776.32	58,278,078.05	77,076,648.09	97,612,255.57
Cavite	11,710,465.19	12,087,944.70	8,576,183.09	11,781,147.56	15,212,732.03	19,713,309.56
Batangas	6,856,484.44	7,295,735.68	4,659,742.63	6,315,678.29	8,967,591.64	11,476,194.74
Occidental Mindoro	506,452.69	507,078.00	288,437.27	321,934.43	429,496.25	535,876.12
Palawan	6,335,248.82	7,586,600.47	4,322,414.66	4,354,829.50	6,762,162.91	9,636,136.53

Table 2.B.18. Value Added at Current Prices of Information and Communication in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Information and Communication at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	2,852,710.22	3,000,519.78	3,128,230.13	3,391,751.69	3,636,273.67	3,937,442.40
Ilocos Sur	2,691,001.66	2,789,143.38	2,940,254.98	3,103,645.91	3,232,858.11	3,523,167.48
La Union	4,144,857.86	4,272,545.71	4,517,313.69	4,784,808.57	5,112,111.44	5,488,280.13
Pangasinan	11,222,401.77	11,703,284.26	12,289,543.78	13,418,402.67	14,162,963.00	15,234,596.85
Cagayan	4,560,552.61	5,037,552.80	5,342,760.78	5,880,650.27	6,210,803.13	6,879,939.20
Batanes	151,735.17	168,292.45	185,637.48	208,002.53	213,639.03	231,273.83
Zambales	5,262,135.76	5,912,399.59	6,726,815.80	7,434,364.58	8,103,602.20	8,703,805.51
Bataan	5,010,580.79	5,986,139.88	6,879,815.39	7,631,691.07	8,462,464.56	8,898,228.28
Pampanga	20,280,979.07	23,669,811.43	26,146,292.26	28,521,111.35	30,774,081.23	32,707,480.17
Bulacan	20,172,406.34	23,519,084.30	26,766,091.90	30,300,246.99	33,396,129.90	35,557,278.92
NCR	133,735,290.19	146,375,899.52	146,443,523.83	154,358,842.67	165,718,040.49	171,873,049.58
Cavite	27,974,549.59	30,370,378.26	33,371,494.24	38,485,080.96	42,413,828.24	43,771,790.94
Batangas	16,815,319.37	18,218,152.41	20,005,893.72	22,838,146.56	24,818,325.04	26,063,854.86
Occidental Mindoro	1,104,247.62	1,252,610.67	1,319,589.02	1,509,398.04	1,651,813.96	1,757,574.61
Palawan	6,267,835.62	6,781,695.23	7,136,324.27	7,549,648.29	7,986,130.44	8,636,996.02

Table 2.B.19. Value Added at Current Prices of Financial and Insurance Activities in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Financial and Insurance Activities at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	2,868,219.00	3,318,802.17	3,666,938.39	3,981,271.93	4,450,361.00	5,059,036.50
Ilocos Sur	3,467,596.06	3,803,184.12	4,179,148.15	4,661,783.84	5,388,385.89	6,122,531.06
La Union	2,802,976.26	3,255,836.26	3,697,162.30	4,061,595.83	4,388,491.75	4,978,502.23
Pangasinan	10,739,078.03	12,257,113.72	13,740,696.85	14,624,615.93	15,847,576.27	18,528,561.84
Cagayan	3,202,883.51	3,709,103.03	4,152,105.89	4,417,246.02	5,038,438.72	5,757,956.67
Batanes	84,413.41	104,503.68	116,258.20	122,672.79	145,267.13	163,628.79
Zambales	4,285,213.32	4,862,365.35	5,303,041.83	5,591,407.27	6,223,252.40	7,079,141.67
Bataan	4,893,663.86	5,338,990.41	5,899,200.04	6,458,321.54	7,225,154.53	8,520,159.81
Pampanga	19,261,752.41	21,551,658.22	24,341,281.86	26,287,548.26	29,087,811.41	34,531,757.55
Bulacan	13,463,966.14	15,114,692.80	16,385,666.17	17,480,265.18	19,966,464.94	24,002,277.22
NCR	931,729,905.59	1,032,701,128.54	1,107,545,269.36	1,183,646,604.18	1,335,758,232.30	1,532,893,897.77
Cavite	27,773,496.68	31,290,124.82	34,864,752.72	38,302,661.18	43,861,633.47	52,594,585.24
Batangas	20,832,525.79	23,441,939.36	25,115,156.74	27,483,803.43	30,438,327.18	37,325,921.65
Occidental Mindoro	2,622,756.06	2,877,212.59	3,281,202.21	3,515,555.33	3,766,325.62	4,321,428.18
Palawan	5,399,365.15	6,075,935.00	6,974,059.96	7,506,808.83	7,884,054.41	9,233,045.87

Table 2.B.20. Value Added at Current Prices of Real Estate and Ownership of Dwellings in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Real Estate and Ownership of Dwellings at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	5,570,980.32	5,845,945.58	5,244,490.28	5,456,913.06	5,810,224.78	6,268,275.43
Ilocos Sur	6,062,976.50	6,439,966.14	5,601,793.35	5,955,127.27	6,501,200.63	7,170,640.80
La Union	7,563,116.06	7,854,081.71	6,624,772.30	6,875,463.87	7,324,036.91	8,154,768.96
Pangasinan	21,937,260.44	22,997,899.03	20,352,902.80	21,376,777.12	23,241,392.08	25,410,388.56
Cagayan	6,832,329.35	7,283,825.84	6,708,354.54	7,225,928.65	7,501,854.61	8,373,054.61
Batanes	128,758.69	135,667.62	136,374.76	146,068.18	157,034.06	166,445.81
Zambales	8,719,484.96	9,429,949.65	7,845,057.62	8,291,716.56	9,201,318.41	10,008,137.47
Bataan	9,751,396.15	10,433,866.14	8,378,923.92	8,817,658.44	9,907,927.97	10,943,214.77
Pampanga	44,618,480.09	49,879,436.41	38,395,924.23	40,725,172.85	45,412,562.69	51,610,669.55
Bulacan	34,376,178.94	36,466,601.52	29,623,178.82	30,477,159.67	33,479,148.06	37,406,319.91
NCR	411,500,203.14	434,540,269.24	364,799,686.20	388,489,883.14	429,588,238.57	471,552,062.16
Cavite	47,599,817.10	49,791,744.41	44,267,621.09	46,933,484.35	50,613,170.79	57,270,963.89
Batangas	39,976,235.45	41,968,227.24	34,888,719.23	36,559,682.63	40,547,595.67	45,338,693.03
Occidental Mindoro	1,122,229.49	1,225,976.37	1,187,037.54	1,269,488.57	1,360,268.46	1,473,555.68
Palawan	5,620,329.64	6,023,700.46	5,772,878.35	5,976,701.27	6,393,380.94	6,838,719.98

Table 2.B.21. Value Added at Current Prices of Professional and Business Services in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Professional and Business Services at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	1,316,771.48	1,335,057.13	1,236,421.28	1,287,721.22	1,409,052.88	1,600,532.54
Ilocos Sur	1,177,819.09	1,194,301.46	1,093,353.32	1,125,686.59	1,205,392.90	1,331,905.04
La Union	1,919,253.30	1,943,708.82	1,793,729.16	1,863,164.05	2,033,438.01	2,271,367.10
Pangasinan	6,017,824.90	6,146,581.85	5,734,639.66	6,020,917.81	6,617,513.13	7,287,291.03
Cagayan	1,190,909.87	1,250,644.55	1,200,456.33	1,341,530.29	1,449,715.59	1,638,153.31
Batanes	103,606.43	106,336.49	99,390.22	109,583.70	120,429.77	139,574.90
Zambales	2,615,667.52	2,778,431.72	2,583,400.16	2,793,064.42	3,055,484.94	3,449,930.60
Bataan	8,779,371.56	9,148,676.46	8,496,396.77	9,316,422.05	10,280,983.39	11,716,342.63
Pampanga	56,887,351.80	61,222,841.13	56,940,761.94	61,404,986.89	67,527,643.55	75,208,071.91
Bulacan	25,528,203.74	27,473,641.93	24,986,983.07	27,218,167.30	30,223,366.30	33,534,540.89
NCR	763,216,236.08	802,257,072.89	749,267,151.77	807,630,295.22	895,529,680.50	978,264,419.87
Cavite	20,800,969.11	21,598,527.63	18,924,423.65	20,287,393.78	22,847,963.05	25,234,834.93
Batangas	11,196,247.13	11,482,621.85	9,721,708.05	10,332,573.89	11,342,257.70	12,325,537.50
Occidental Mindoro	592,816.33	691,001.13	720,531.00	747,968.14	813,498.35	906,637.83

Localities	Professional and Business Services at Current Prices					
	2018	2019	2020	2021	2022	2023
Palawan	1,546,405.64	1,687,849.23	1,726,953.30	1,902,304.26	2,094,328.48	2,338,897.77

Table 2.B.22. Value Added at Current Prices of Public Administration & Defense and Compulsory Social Activities in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025)

Localities	Public Administration & Defense and Compulsory Social Activities at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	2,289,206.87	2,701,138.43	2,879,367.50	3,010,480.78	3,275,611.96	3,652,679.19
Ilocos Sur	2,930,035.57	3,243,227.52	3,576,090.14	3,812,171.88	4,254,959.42	4,820,104.78
La Union	4,674,563.69	5,396,622.58	5,621,828.65	6,045,851.05	6,633,604.03	7,567,375.30
Pangasinan	7,127,858.49	8,105,775.57	8,649,259.16	8,954,329.61	9,822,176.44	11,212,538.83
Cagayan	3,968,677.63	4,392,253.65	4,483,865.59	5,018,095.03	5,516,314.75	6,035,458.75
Batanes	325,814.76	372,648.30	385,798.75	436,935.88	470,406.08	504,240.02
Zambales	3,454,199.64	3,888,143.23	4,139,430.43	4,464,996.57	5,095,935.18	5,267,065.23
Bataan	2,606,164.19	2,997,995.58	3,097,208.81	3,669,475.21	4,210,280.63	4,218,125.23
Pampanga	10,979,101.92	11,745,908.03	12,606,292.29	14,582,795.80	16,547,818.21	16,452,313.19
Bulacan	6,913,749.26	8,100,079.62	7,938,963.94	8,725,727.72	9,459,066.57	9,201,839.34
NCR	435,304,730.22	509,592,978.92	549,937,699.42	585,210,005.35	634,922,769.03	652,711,226.25
Cavite	10,328,054.71	12,348,475.01	13,838,587.96	15,900,490.30	17,603,548.59	18,850,742.84
Batangas	12,512,494.39	14,094,534.43	14,475,672.97	16,600,185.97	17,823,518.54	19,653,942.14
Occidental Mindoro	1,628,708.17	1,626,429.83	1,762,772.59	1,899,951.45	2,171,925.77	2,549,677.02
Palawan	4,800,883.77	5,064,530.99	5,437,647.43	5,560,940.62	6,149,415.67	7,292,329.34

Table 2.B.23. Value Added at Current Prices of Education in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025)

Localities	Education at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	4,262,017.55	4,497,602.95	4,341,818.25	4,766,401.82	5,239,117.70	5,966,938.22
Ilocos Sur	4,832,353.42	5,092,227.02	5,024,214.28	5,444,582.37	6,079,808.48	6,745,135.13
La Union	5,592,733.97	5,790,141.42	5,411,406.96	5,921,328.81	6,511,213.36	7,115,248.34
Pangasinan	20,382,188.77	21,390,056.01	20,476,395.65	22,568,195.55	24,576,213.59	26,486,419.20
Cagayan	8,465,164.85	8,758,648.70	8,493,824.09	9,488,062.89	10,458,368.22	11,223,377.67
Batanes	329,456.70	334,225.12	333,658.08	381,349.16	418,126.07	454,308.62
Zambales	5,578,677.60	5,795,420.67	5,643,059.64	6,186,190.02	6,850,312.69	7,497,519.80
Bataan	5,265,318.39	5,384,194.36	5,192,017.09	5,726,490.58	6,407,819.34	7,066,099.87
Pampanga	16,878,490.50	17,395,860.28	17,141,826.78	18,379,682.07	20,240,502.48	22,235,871.68

Localities	Education at Current Prices					
	2018	2019	2020	2021	2022	2023
Bulacan	20,352,896.44	20,608,463.66	19,877,921.27	21,666,088.94	23,794,456.09	26,209,327.78
NCR	149,189,048.92	160,634,199.11	118,294,644.33	130,602,551.76	141,931,543.98	159,239,357.20
Cavite	26,979,050.14	27,931,699.16	27,497,341.86	30,185,204.77	33,280,062.27	36,453,103.98
Batangas	18,170,997.01	19,017,223.02	18,662,079.35	20,710,894.16	23,399,721.47	26,756,167.00
Occidental Mindoro	2,907,861.07	2,991,391.23	3,020,497.08	3,412,872.75	3,775,043.73	4,123,143.74
Palawan	7,032,909.93	7,011,221.08	7,000,423.06	7,925,949.41	8,702,548.48	9,628,384.96

Table 2.B.24. Value Added at Current Prices of Human Health and Social Work Activities in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025)

Localities	Human Health and Social Work Activities at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	1,395,085.79	1,480,416.99	1,616,578.54	1,946,636.78	2,106,275.13	2,343,230.21
Ilocos Sur	2,340,862.80	2,559,238.29	2,752,958.83	3,250,125.82	3,619,222.73	4,037,544.82
La Union	1,984,139.50	2,105,573.76	2,246,646.38	2,716,609.49	2,948,342.23	3,252,021.55
Pangasinan	6,056,627.02	6,653,781.69	6,968,978.57	8,803,390.78	9,461,676.02	10,416,624.19
Cagayan	2,592,824.43	3,035,481.24	3,310,532.53	4,041,659.98	4,251,183.32	4,766,774.47
Batanes	116,025.72	136,359.86	156,760.01	182,089.89	194,975.37	217,044.43
Zambales	1,166,065.01	1,248,475.04	1,347,093.86	1,702,834.60	1,859,356.10	2,038,756.23
Bataan	1,638,730.86	1,811,043.88	1,884,849.61	2,427,724.86	2,565,985.46	2,881,916.52
Pampanga	8,179,193.33	8,929,549.27	8,841,408.32	11,309,657.39	12,030,706.29	13,481,115.48
Bulacan	6,122,217.26	6,559,773.16	6,662,946.25	8,541,106.82	9,152,585.03	10,074,032.40
NCR	107,408,616.21	112,958,116.75	111,586,939.82	124,422,924.35	129,781,500.05	146,838,075.65
Cavite	8,595,653.82	9,338,655.62	8,188,783.97	10,233,409.15	10,901,700.92	12,012,736.11
Batangas	6,205,688.87	6,851,075.37	5,830,130.08	7,145,654.03	7,606,299.92	8,484,973.61
Occidental Mindoro	445,411.58	520,283.56	555,048.05	664,955.69	738,288.14	803,297.13
Palawan	1,855,329.20	2,002,890.43	2,155,065.54	2,745,775.74	3,020,311.35	3,272,547.36

Table 2.B.25. Value Added at Current Prices of Other Services in Different Localities from 2018 to 2023 (Philippine Statistics Authority, 2025).

Localities	Other Services at Current Prices					
	2018	2019	2020	2021	2022	2023
Ilocos Norte	1,516,857.93	1,671,853.16	844,170.17	916,714.76	1,358,889.60	1,791,597.10
Ilocos Sur	1,381,901.44	1,605,788.90	1,050,738.03	1,105,575.78	1,508,118.22	1,867,755.23
La Union	3,212,624.54	3,672,392.34	2,313,795.67	2,497,275.19	3,224,124.65	3,828,044.74
Pangasinan	7,648,018.16	8,751,180.27	5,253,075.11	5,428,179.37	7,713,252.70	9,166,889.95

Localities	Other Services at Current Prices					
	2018	2019	2020	2021	2022	2023
Cagayan	1,712,591.93	1,950,523.57	704,011.65	721,345.15	837,508.18	1,114,762.83
Batanes	94,573.06	109,900.75	52,860.81	50,849.66	63,430.98	79,417.11
Zambales	6,428,362.06	6,717,319.92	3,819,443.74	3,954,194.51	5,433,024.61	7,343,086.38
Bataan	6,760,223.03	7,652,273.36	5,296,074.52	5,292,883.23	6,352,735.65	8,465,314.64
Pampanga	17,636,347.60	19,284,404.55	12,791,861.82	13,114,500.79	16,152,027.81	21,970,104.09
Bulacan	13,678,740.40	14,966,820.24	11,586,114.33	11,706,112.92	14,676,286.77	20,003,525.91
NCR	176,236,765.65	179,140,305.09	92,668,023.53	95,335,166.45	130,790,323.57	163,596,339.82
Cavite	11,279,460.17	14,262,358.31	9,565,655.80	9,801,381.66	13,962,292.47	17,770,292.93
Batangas	7,491,103.25	9,307,342.17	6,338,175.61	6,504,882.38	9,007,274.52	11,386,609.86
Occidental Mindoro	1,320,162.20	1,468,664.09	1,418,413.39	1,506,882.70	1,734,910.75	2,242,168.92
Palawan	5,900,308.32	6,845,731.21	6,061,127.97	6,214,365.94	7,177,519.53	9,172,044.35

Annex 2.C. Climate-Related Threats Database

Table 2.C.1. Reported Deaths Caused by Tropical Cyclones and Typhoons in 2024 (Sources: Adriano, 2024; Argosino, 2024; Baccay, 2024; Chavez, 2024; Citizens Disaster Response Center, 2024; Corrales, 2024; Delizo, 2024; Mallari et al., 2024; Ombay, 2024; Peralta-Malonzo, 2024; Philippine Daily Inquirer, 2024; Reyes & Corrales, 2024; Rita, 2024; Serquiña, 2024; Tupas, 2024).

Localities	Reported Deaths (2024)							Total Deaths
	Typhoon 'Gaemi' (Carina) and 'Butchoy' (Prapiroon)	Typhoon 'Man-yi' (Pepito)	Tropical cyclone 'Ewiniar' (Aghon)	Typhoon 'Yinxing' (Marce)	Typhoon 'Yagi' (Enteng)	Tropical cyclone 'Trami' (Kristine)	Tropical cyclone 'Krathon' (Julian)	
Ilocos Norte	0	0	Not affected	0	0	0	3	3
Ilocos Sur	0	0	Not affected	0	0	0	2	2
La Union	3	0	Not affected	0	0	1	0	4
Pangasinan	0	0	Not affected	0	0	0	0	0
Cagayan	0	0	0	1	0	0	1	2
Batanes	0	0	0	0	0	0	0	0
Zambales	0	0	0	0	0	1	0	1
Bataan	0	0	0	0	0	0	0	0
Pampanga	2	0	0	0	0	0	0	2
Bulacan	1	0	0	0	0	0	0	1
NCR	7	Not affected	Not affected	Not affected	0	0	Not affected	7
Cavite	3	0	0	Not affected	0	2	Not affected	5
Batangas	5	0	0	Not affected	0	59	Not affected	64
Occidental Mindoro	0	Not affected	0	Not affected	0	0	Not affected	0
Palawan	0	Not affected	0	Not affected	0	0	Not affected	0

Table 2.C.2. Exposed Population to Hazards of Localities in 2021 (Pacific Disaster Center, 2021)

Localities	Expanded Population (2021)				
	Storm Surge	Typhoon Winds	Tsunami	Flooding	Landslide
Ilocos Norte	52,043	602,529	21,214	288,430	48,052
Ilocos Sur	198,424	695,732	27,226	357,295	85,180
La Union	171,657	774,641	1,943	414,075	108,773
Pangasinan	418,948	3,012,852	2,779	2,519,870	33,433
Cagayan	133,166	1,214,848	30,602	761,769	57,810
Batanes	770	16,892	2,605	N/A	7,350
Zambales	364,969	817,210	9,232	536,358	47,034
Bataan	246,213	732,954	23,170	650,483	39,676
Pampanga	41,754	2,394,057	17,077	2,369,805	18,317
Bulacan	133,976	3,049,630	3,864	2,315,664	40,519
NCR	2,763,038	5,537,318	83,777	9,020,292	13
Cavite	618,628	3,588,574	51,671	1,583,688	79,389
Batangas	231,741	2,618,273	2,675	295,130	295,130
Occidental Mindoro	225,885	508,887	7,607	435,832	61,925
Palawan	265,452	711,283	28,707	561,330	140,555

Table 2.C.2. (Continuation...)

Localities	Expanded Population (2021)				
	Earthquake	Liquefaction	Volcanic Eruption	Wildfire	Drought
Ilocos Norte	574,459	428,177	No Data	57,438	559,690
Ilocos Sur	657,276	545,463	No Data	27,501	No Data
La Union	657,076	463,376	No Data	30,686	No Data
Pangasinan	2,901,032	2,493,193	5,270	288,385	No Data
Cagayan	1,157,750	920,953	14,030	64,746	1,189,166
Batanes	No Data	No Data	9,221	No Data	No Data
Zambales	742,845	606,064	5,682	297,349	No Data
Bataan	713,792	345,695	2,371	26,308	No Data
Pampanga	2,394,038	2,272,356	25,369	392,777	No Data
Bulacan	3,046,986	1,505,029	9,146	459,719	8,088
NCR	12,556,544	5,714,230	37,861	5,537,318	No Data
Cavite	3,448,145	1,160,444	25,798	57.8 million	No Data
Batangas	2,499,998	345,203	132,997	107,625	No Data
Occidental Mindoro	396,699	253,862	366	145,385	1,776
Palawan	No Data	395,160	No Data	56,465	659,707

Table 2.C.3. Exposed Capitals to Hazards of Localities in 2021 (Pacific Disaster Center, 2021)

Localities	Exposed Capital (USD) (2021)				
	Storm Surge	Typhoon Winds	Tsunami	Flooding	Landslide
Ilocos Norte	170,200,000	3,100,000,000	51,900,000	1,600,000,000	108,200,000
Ilocos Sur	1,300,000,000	3,600,000,000	59,300,000	2,300,000,000	217,300,000
La Union	1,200,000,000	4,400,000,000	2,400,000	2,700,000,000	332,000,000
Pangasinan	1,900,000,000	14,900,000,000	7,900,000	12,600,000,000	166,800,000
Cagayan	617,700,000	8,200,000,000	163,100,000	6,400,000,000	156,000,000
Batanes	Not Applicable	55,500,000	1,600,000	Not Applicable	27,000,000
Zambales	782,300,000	1,500,000,000	4,300,000	912,600,000	73,400,000
Bataan	870,600,000	1,900,000,000	8,900,000	1,700,000,000	72,600,000
Pampanga	16,000,000	5,500,000,000	5,800,000	5,500,000,000	25,400,000
Bulacan	2,000,000,000	13,100,000,000	5,200,000	10,500,000,000	27,200,000
NCR	33,700,000,000	5,537,318	434,500,000	119,600,000,000	Not Applicable
Cavite	1,700,000,000	3,588,574	32,200,000	6,300,000,000	101,100,000
Batangas	744,700,000	6,900,000,000	6,600,000	295,130	295,130
Occidental Mindoro	343,800,000	1,200,000,000	7,600,000	1,100,000,000	129,200,000
Palawan	321,000,000	1,100,000,000	10,200,000	1,100,000,000	310,100,000

Table 2.C.3. (Continuation...)

Localities	Exposed Capital (USD) (2021)				
	Earthquake	Liquefaction	Volcanic Eruption	Wildfire	Drought
Ilocos Norte	3,000,000,000	2,400,000,000	<10,000	353,300,000	2,900,000,000

Ilocos Sur	3,500,000,000	3,200,000,000	Not Applicable	92,900,000	Not Applicable
La Union	3,800,000,000	3,000,000,000	Not Applicable	184,200,000	Not Applicable
Pangasinan	14,700,000,000	12,500,000,000	26,300,000	1,700,000,000	Not Applicable
Cagayan	8,000,000,000	7,200,000,000	49,400,000	499,100,000	8,200,000,000
Batanes	Not Applicable	Not Applicable	19,700,000	Not Applicable	Not Applicable
Zambales	1,400,000,000	1,200,000,000	15,600,000	711,200,000	Not Applicable
Bataan	1,800,000,000	1,200,000,000	6,000,000	20,000,000	Not Applicable
Pampanga	5,500,000,000	4,900,000,000	74,800,000	682,800,000	Not Applicable
Bulacan	13,100,000,000	7,400,000,000	39,200,000	2,900,000,000	970,487
NCR	156,100,000,000	74,200,000,000	472,000,000	5,537,318	Not Applicable
Cavite	10,300,000,000	4,700,000,000	57,800,000	6,800,000,000	Not Applicable
Batangas	6,800,000,000	1,200,000,000	290,500,000	416,500,000	Not Applicable
Occidental Mindoro	1,100,000,000	728,500,000	637,485	444,900,000	3,500,000
Palawan	Not Applicable	679,000,000	Not Applicable	154,000,000	1,500,000,000

Aquatic Pollution in the Philippine Waters of South China Sea Large Marine Ecosystem (SCS-LME)

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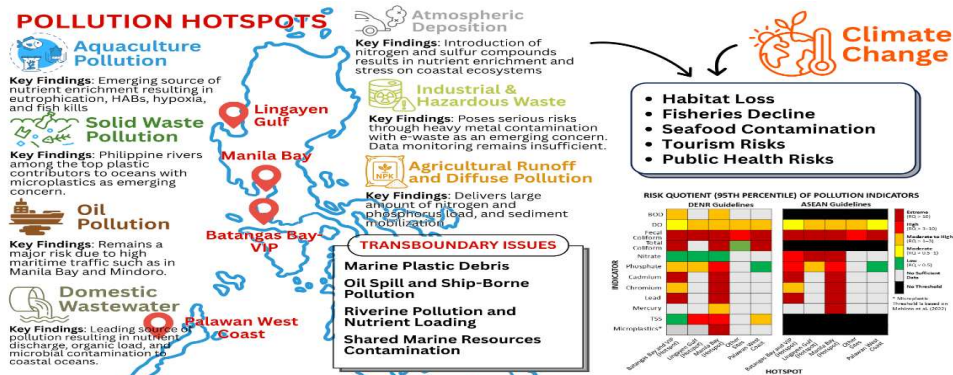
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Abstract

Marine pollution poses one of the most persistent threats to the ecological and socio-economic sustainability of Philippine waters bordering the South China Sea Large Marine Ecosystem (SCS-LME). This chapter provides an updated assessment (2000–2024) of major pollution sources, pathways, and impacts. Domestic wastewater remains the dominant contributor, with less than 20% of the generated sewage being treated, and the majority being discharged untreated into estuaries and bays. Agricultural runoff and diffuse sediment pollution contribute significantly to nitrogen and phosphorus loads, intensifying eutrophication and harmful algal blooms in semi-enclosed systems, such as Manila Bay and Lingayen Gulf. Aquaculture and mariculture have further increased nutrient inputs, chemical residues, and antibiotic contamination, while industrial effluents remain a chronic source of heavy metals and hazardous chemicals. Solid waste and marine litter, particularly plastics, have rapidly emerged as critical national and transboundary concerns. The Philippines was identified as one of the world’s leading sources of riverine plastic leakage to the ocean. Oil spills, ballast discharges, and atmospheric deposition compound risks, particularly in high-traffic and industrialized coastal areas. The analysis identifies Manila Bay, Lingayen Gulf, Batangas Bay, and Palawan’s west coast as pollution hotspots, where ecological degradation intersects with fisheries decline, and tourism risks. Despite advances in environmental legislation and participation in regional initiatives, implementation gaps and limited infrastructure investment persist. Scientific data on persistent or emerging organic pollutants, pharmaceuticals, and microplastics in Philippine estuarine and coastal systems also remain scarce. Addressing these knowledge and management gaps is essential for evidence-based policymaking and for safeguarding the biodiversity and blue economy potential of the SCS-LME.

Keywords: Marine pollution, South China Sea, Philippines, plastic leakage, emerging contaminants

Graphical Abstract



3. Pollution

Philippine coastal waters which face the South China Sea Large Marine Ecosystem (SCS-LME) are under significant pollution pressure. As a middle-income country in the ASEAN region with 36,289 km of coastline and a population exceeding 110 million, the country's strategic position at the center of the Coral Triangle makes effective pollution management crucial. Since the 2000 Transboundary Diagnostic Analysis (Talaue-McManus, 2000), the Philippines has strengthened its legal framework through the Clean Water Act and Ecological Solid Waste Management Act, developed integrated coastal management approaches, and increased participation in regional initiatives (Environmental Management Bureau [EMB], 2021a; EMB, 2022). However, rapid urbanization has outpaced infrastructure development, agricultural intensification continues to increase nutrient loads, and plastic pollution has emerged as a critical threat, further compounded by the effects of climate change.

3.1 Key Findings

- Domestic wastewater is the leading source of pollution, with less than 20% of the urban population connected to treatment systems, resulting in untreated discharges of nutrients, organics, and pathogens.
- Agricultural runoff delivers large nitrogen and phosphorus loads, fueling eutrophication and harmful algal blooms; upland erosion adds sediments that degrade reefs and seagrasses.
- Solid waste and plastics are highly visible and persistent, with Philippine rivers ranked among the top global contributors of plastic leakage to the ocean.
- Industrial effluents and hazardous wastes, including heavy metals, industrial by-products, and increasing e-waste, pose localized but serious risks; however, monitoring and data remain fragmented and incomplete.
- Oil pollution from vessel discharges and tanker accidents remains a major risk in high-traffic areas such as Manila Bay and Batangas Bay.
- Aquaculture and mariculture are emerging sources of nutrient enrichment and organic loading, contributing to localized hypoxia, fish kills, and harmful algal blooms (HAB) in semi-enclosed bays.
- Atmospheric deposition could introduce reactive nitrogen and sulfur compounds from power plants, vehicles, and biomass burning, creating an additional pathway for acidification, nutrient enrichment, and stress on coastal ecosystems.
- Hotspots including Manila Bay, Lingayen Gulf, and Batangas Bay-Verde Island Passage show consistently elevated microbial contaminants, nutrients, organic, and heavy-metal levels. The west coast of Palawan is an emerging hotspot.
- Emerging contaminants, notably persistent organic micropollutants, pharmaceuticals, and microplastics, are of growing concern, but scientific monitoring in Philippine coastal and estuarine waters remains scarce.
- Impacts include degraded habitats (corals, seagrass, mangroves), fishery decline, seafood contamination, tourism risks, and public health hazards.
- Climate change is expected to exacerbate pollution impacts through intensified rainfall, increased runoff, sea-level rise, and extreme events, which in turn increase contaminant mobilization.

3.2 Current Status by Indicator Group

3.2.1 Pollution Sources and Magnitude

Understanding the sources and magnitude of pollution is critical to assessing its ecological and socio-economic impacts on Philippine waters within the SCS-LME. This section examines the dominant land- and sea-based inputs, quantifying their contributions and highlighting persistent and emerging hotspots. See Annex 3.A for the definition of pollution indicators.

3.2.1.1 Domestic Wastewater

Domestic wastewater remains the largest contributor to marine pollution. Metro Manila generated over 800 Mm³/year wastewater in 2023, with only 16% treated (Figure 3.1). Wastewater treatment facilities increased from 56 in 2014 to 65 in 2020, while normalized treatment capacity by number of facilities grew steadily to nearly 2 Mm³/facility by 2023. This indicates improvements could come primarily from expanding existing plants rather than building new facilities (Figure 3.2). In 2015, less than 15% of the national population was connected to sewer systems (National Economic and Development Authority [NEDA], 2021). Metropolitan Waterworks and Sewerage System (MWSS) concessionaires in Metro Manila served approximately 2.20 million in septage and 2.40 million in sewerage services (Annex Figure 3.B.1), representing less than 3 percent of the national population. Limited coverage is thus expected to be more pronounced in rapidly expanding peri-urban areas along Manila Bay, Lingayen Gulf, and other population centers.

Domestic wastewater contributes about a third of total BOD nationwide (Annex Figure 3.B.2.) in terms of water pollution (EMB, 2020a). The limited infrastructure results in an estimated pollution load of 530,000 ± 30,000 tons/year BOD reaching coastal waters (SCS-LME) by 2025 (Annex Table 3.B.6), a 23% increase from 2000 reported by Talaue-McManus (2000). Nutrient loading contributes 93,000 ± 5,000 tons of nitrogen and 15,000 ± 700 tons of phosphorus annually (See Annex 3.B for complete calculation on pollution load estimates). Fecal coliform levels in major waterways exceed 10⁵-10⁶ MPN/100mL, well above the 200 MPN/100mL standard. Manila Bay Office of EMB reported from 2011-2015 (19 monitoring stations) that the average FC count ranges from 5.4×10³ to 2.6×10⁴ MPN, reflecting pervasive contamination at Manila Bay. According to EMB projections of pollution load (EMB, 2020a), Region 4A consistently contributes the highest pollutant loads among the regions affecting the Philippine Waters of SCS-LME, followed by the National Capital Region (NCR) and Region 3, particularly affecting Manila Bay (Annex Figure 3.B.4).

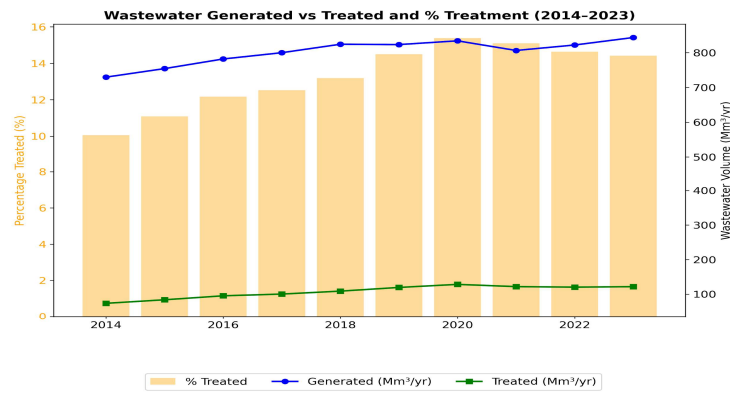


Figure 3.1. Wastewater generation and treatment trends in Metro Manila from 2014-2023. Data Source: PSA, 2024.

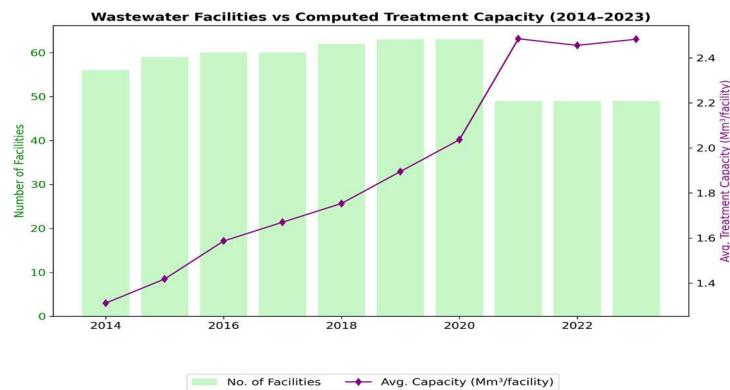


Figure 3.2. Trend of wastewater facilities and treatment capacity in Metro Manila from 2014-2023. Data source: PSA, 2024

Domestic wastewater contributes approximately 47,000 tons of nitrogen and 4,500 tons of phosphorus annually to Manila Bay, with the highest loads from densely populated Metro Manila (19,137 people/km²) and surrounding coastal provinces. This nutrient enrichment causes documented eutrophication and hypoxic conditions, with oxygen levels dropping to 2.1 mg/L during wet seasons. Nitrogen loads could increase by 27-469% by 2050, depending on population growth and sewage treatment improvements (Sotto et al., 2015).

Submarine groundwater discharge (SGD) represents another significant source of nutrient pollution in coastal waters, potentially transporting contaminated groundwater from terrestrial sources and coastal communities. In Bolinao, groundwater wells showed high ammonia concentrations (19-76 μ M), indicating "areas of intense ammonification" from septic waste plumes (Senal et al., 2011). SGD also appears to be a significant source of inorganic nitrogen to Manila Bay, contributing fluxes equivalent to 42% from the Pampanga River and 96% of the Pasig River input (Taniguchi et al., 2008). These nutrient inputs stimulate dinoflagellate and cyanobacteria growth, triggering HABs formation and perpetuating the eutrophication-bloom-mortality cycle (Santos et al., 2021). The convergence of aquaculture-derived nutrients and SGD inputs could create multi-source pollution which amplifies the risk of ecological disruption in marine ecosystems.

Domestic wastewater is also a source of emerging contaminants such as PFAS (e.g., PFOS), pharmaceuticals, and endocrine disruptors, which can evade conventional treatment and pose a risk to human health and aquatic ecosystems (Guardian et al., 2020; Mariano et al., 2023). However, monitoring in Philippine coastal and estuarine waters remains scarce.

3.2.1.2 Industrial Effluents

Industrial activities generate significant pollution despite regulatory improvements. As of 2020, 820,253 industrial establishments operate nationwide, with 60% in the Manila Bay region (Tuddao, Jr., and Gonzales, 2020). Of these, 112,789 qualify as manufacturing plants, while the remainder include utilities, construction yards, repair shops, logistics depots, and other non-manufacturing facilities. Major sectors include food processing, textiles, electronics, and petroleum refining (Annex Table 3.B.9). Water Environment Partnership in Asia [WEPA] (2024) reports on the typical wastewater quality of these selected industries (Annex Table 3.B.10). Across the ten industries profiled, wastewater characteristics vary dramatically, reflecting the diversity of Philippine manufacturing processes. Industrial sources contribute 27-33% of the BOD load. Compliance rates remain low at 46% nationally and 35% in NCR (WEPA, 2021; Uyaco, 2022).

While industrial discharges contribute a smaller volume than agricultural and domestic sources (WEPA, 2024), their environmental impact is significantly greater due to their toxic composition. Industrial effluents often contain heavy metals, oils, and hazardous chemical wastes. For example, heavy metal contamination has reached severe levels in several rivers, such as the Marilao-Meycauayan-Obando River System (Pleto et al., 2020).

3.2.1.3 Agricultural Runoff and Diffuse Pollution

Agricultural intensification has led to a significant increase in fertilizer and pesticide use. Nitrogen application rose from 488,000 to 799,000 tons/year (2000-2022), while phosphorus and potassium showed over 200% increases (Annex Figure 3.C.1; see Annex 3.C for time-series graphs). Pesticide use increased from 50,000 to 85,000 tons/year (Annex Figure 3.C.2.). Rice cropping contributes approximately 23,706 tons of nitrogen to Manila Bay annually, representing a 51% loss of applied fertilizer (Magcale-Macandog et al., 2016). These inputs fuel eutrophication and harmful algal blooms in semi-enclosed bays.

Excessive fertilizer applications in Northern and Central Luzon exceed 100 kg N/ha in some provinces. Pampanga River monitoring showed phosphorus concentrations of 0.30-0.67 ppm (wet season) and 0.5-0.9 ppm (dry season) approaching Manila Bay, well above the 0.02 ppm threshold for algal growth (Magcale-Macandog et al., 2016). A breakdown of nutrient loading into Manila Bay from the four major contributing sub-watersheds is shown in Figure 3.3. The Pasig River Basin would dominate nitrate ($\text{NO}_3\text{-N}$) loading, reflecting dense urban populations and untreated domestic wastewater inflows from Metro Manila. On the one hand, the Bataan Watershed would contribute the largest share of total phosphorus, likely driven by agricultural fertilizer runoff and soil erosion.

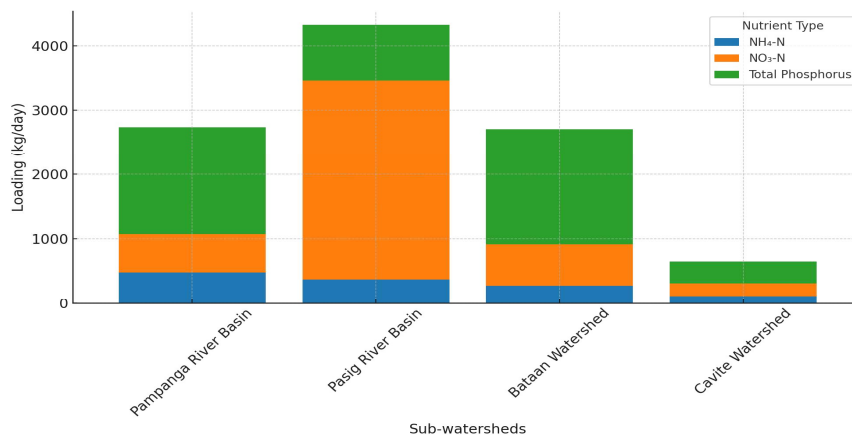


Figure 3.3. Stacked nutrient loading to Manila Bay by sub-watershed. Data source: Samar (2012) as cited in Magcale-Macandog et al. (2016)

Pesticide residues from agricultural runoff reach coastal waters, detected in rivers flowing into Lingayen Gulf and Manila Bay. While Pampanga River samples showed concentrations below the Limit of Quantitation ($0.1 \mu\text{L/L}$), paddy field drainage water contained higher residues ($0.001\text{-}3.46 \text{ ppb}$) than inflow water ($0.01\text{-}0.54 \text{ ppb}$). Isotopic mass balance analysis also revealed that 17-30% of the organic matter deposited in Manila Bay originates from agricultural activities (Bureau of Soils and Water Management (BSWM), 2013, as cited in Magcale-Macandog et al., 2016), providing direct evidence of agriculture's contribution to marine pollution in the Philippine Waters of the SCS-LME.

In addition to nutrient and pesticide inputs from runoff, diffuse sediment mobilization from upland erosion and land conversion has a significant impact on coastal waters. This sediment carries contaminants such as heavy metals, absorbed nutrients, and pesticides, creating multiple pollution pathways. Sediment loads from deforestation, mining activities, and poorly managed farms also increase turbidity which can smother sensitive habitats such as coral reefs and seagrass beds. Lingayen Gulf, for example, experiences heavy siltation from the Agno River system, degrading fisheries and benthic ecosystems (Deocadez et al., 2003).

3.2.1.4 Aquaculture and Mariculture Pollution

Aquaculture provides food security and economic opportunities in the Philippines, but has become a major source of nutrient enrichment and chemical pollution. In Manila Bay and Bolinao Bay, fishponds, pens, and mariculture systems discharge nitrogen, phosphorus, heavy metals, and antibiotic residues into surrounding ecosystems (Tahiluddin et al., 2025).

Between 2011 and 2018, fishponds around Manila Bay accounted for 41.19% of national aquaculture production (Baldoza et al., 2020). These produce effluents with ammonia-nitrogen ($0.90\text{-}2.35 \text{ mg/L}$) and phosphate ($1.02\text{-}2.42 \text{ mg/L}$) exceeding thresholds suitable for fish culture. The phosphate levels in Manila Bay also reach 0.03 mg/L , exceeding the marine water quality criterion of 0.015 mg/L (PEMSEA, 2004). Nutrient load estimations

indicate that aquaculture around Manila Bay contributes approximately 12,697 metric tons of nitrogen and 2,363 metric tons of phosphorus annually, with fish pens/cages accounting for 88% of nitrogen and 86% of phosphorus loads (Montejo et al., 2020). In Bolinao Bay, nutrient discharges from milkfish pens cause localized acidification, deterioration of water quality, fish kills, and declining coral cover (San Diego-McGlone et al., 2008; Isah et al., 2022). Waste excrements and leftover fish feeds increase the amount of phosphorus, affecting the N/P ratio in Bolinao during the dry season. This phosphorus-rich environment becomes susceptible to algal blooms when nitrogen-containing freshwater arrives during the wet season (Ferrera et al., 2016).

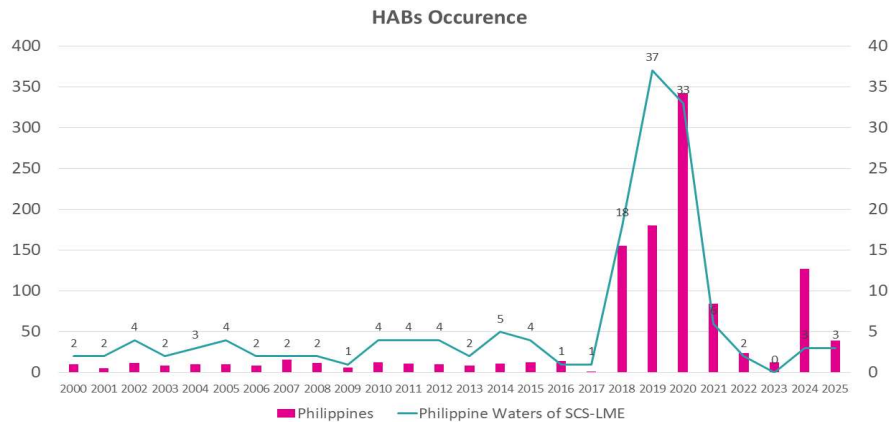


Figure 3.4. Occurrence of Harmful Algal Bloom in the Philippines and in the Philippine Waters of SCS-LME (2000-2025). Data source: Intergovernmental Oceanographic Commission, 2025.

Nutrient enrichment also drives harmful algal blooms (HABs), which threaten marine ecosystems and human health through the production of toxins. HAB events directly impact fisheries and aquaculture, including fish kills and shellfish toxicity. The Philippines' Bureau of Fisheries and Aquatic Resources (BFAR) issues shellfish advisories indicating paralytic shellfish toxin (PST) contamination (See Annex 3.D). From the national data, there is an increase in HABs occurrences in the late 2010s to 2020s, peaking at 342 recorded occurrences in 2020 (Figure 3.4). Fish kill events persist, particularly in Bolino-Anda, Pangasinan, where intensive aquaculture operations create hypoxic conditions for mass mortality (Annex Table 3.D.1). The 2002 Bolinao fish kill coincided with a *Prorocentrum cordatum* bloom, demonstrating the linkage between eutrophication, HABs, and fish mortality (San Diego-McGlone et al., 2024).

Beyond nutrient pollution, aquaculture is also a growing source of chemical contaminants. Heavy metals, including cadmium, lead, chromium, and mercury, accumulate in sediments and fish, threatening food safety (Tahiluddin, et al., 2025). Antibiotic use, particularly oxytetracycline, promotes the development of antibiotic-resistant bacteria, with the Philippines identified as a potential hotspot for antimicrobial resistance (AMR) in aquaculture.

3.2.1.5 Solid Waste and Marine Litter

The Philippines faces a rapidly growing solid waste challenge, driven by economic and population pressures. Municipal solid waste (MSW) reached more than 40,000 tons/day in 2016 (Talavera et al., 2024) from 37,400 tons/day in 2012, and is projected to exceed 60,000 tons/day by 2023. Regional hotspots include Metro Manila, CALABARZON, and Central Luzon, with NCR alone surpassing 9,000 tons/day (Figure 3.5). Recent data from EMB confirm 61,000 tons/day in 2024, equivalent to 22–23 million tons annually, with plastics comprising 24% of the mix. These values closely align with government projections, underscoring a persistent upward trend.

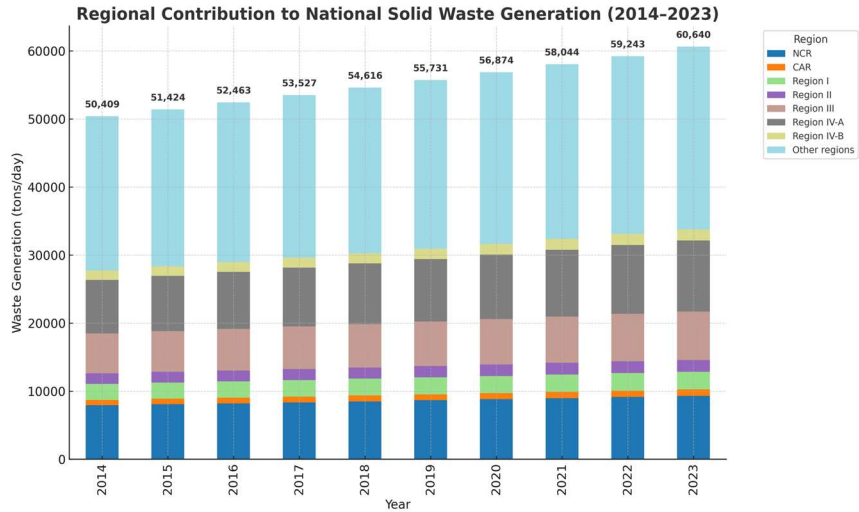


Figure 3.5. Projected Annual Solid Waste Generation and Regional Contribution from 2014-2023 (PSA, 2024)

Infrastructure, however, lags behind the demand. By 2023, the country had 11,823 material recovery facilities and 299 sanitary landfills, which fell short of the required number (Figure 3.6). Commission on Audit (COA) reports highlight chronic under-resourcing, with many barangays lacking proper facilities and resorting to open dumping or burning (Baclig, 2024). The waste composition is dominated by biodegradable material (52.31%), followed by recyclables such as paper, metals, glass, and plastics (EMB, 2020b). Plastic waste accounts for 10–11% of MSW by weight, but is disproportionately visible in waterways and seas.

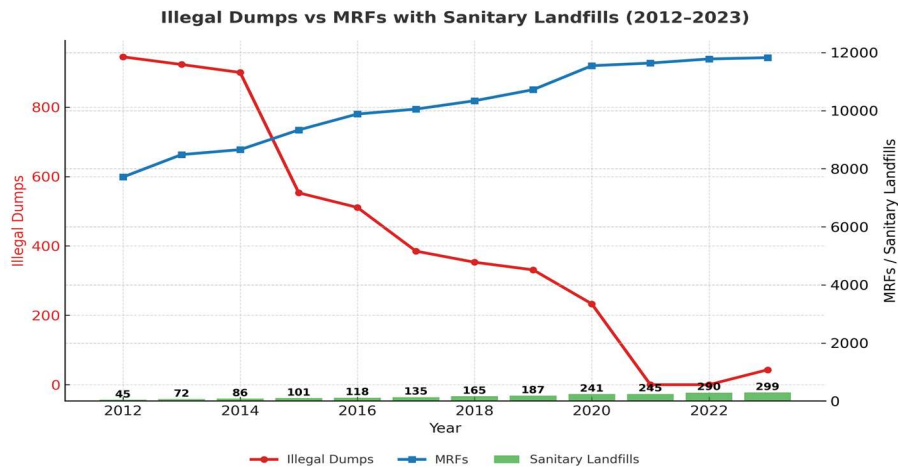


Figure 3.6. Trend on the Number of Disposal Facilities in the Philippines (2012-2023) Data source: PSA, 2024

The Philippines is thus identified as a leading contributor of marine litter from plastic waste leakage, with 0.75 million tons entering the ocean annually (World Bank Group, 2021). Modeled studies (Meijer et al., 2021) estimate over 150,000 tons/year flow through rivers, nine of which drain into the South China Sea LME, as shown in Figure 3.7 (see Annex 3.E for the complete list of rivers in the Philippines). Surveys in Manila Bay reveal more than 90% of beach debris is plastic, while mangrove habitats are increasingly clogged, impairing ecosystem services (Chaigne, 2021). Despite recent cleanup campaigns (GMA Integrated News, 2025), systemic solutions remain urgent.

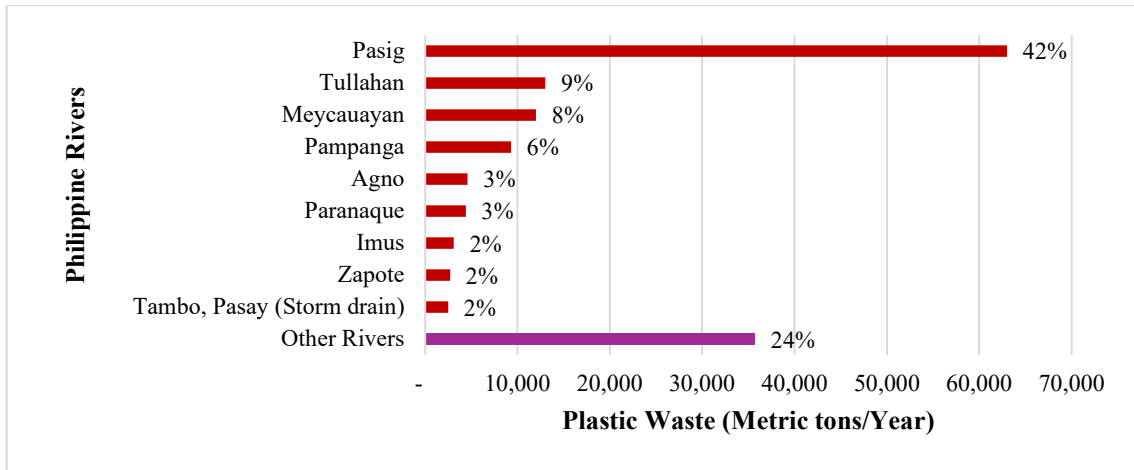


Figure 3.7. Top Plastic Emitting Rivers in the Philippines Draining to the Philippine waters of SCS-LME from the modeling study of Meijer et al. (2021). Percentages shown indicate the proportion of each river's contribution to the national total.

3.2.1.6 Hazardous Waste

Hazardous waste comprises substances with no safe commercial use that are generated from industrial, chemical, or related activities, that are toxic, corrosive, flammable, reactive, infectious, or otherwise harmful. Proper handling, treatment, and disposal are critical to prevent risk to human health and environmental contamination. From 2012 to 2023, oil waste (9 million tons), inorganic chemicals (4.9 million tons), and cyanide waste (4.3 million tons) dominated hazardous waste generation (Figure 3.8). Region 4A, Region 3, and the National Capital Region (NCR) consistently account for more than 80% of national output from 2020-2023 (Figure 3.9). Reported treatment rates improved to 92% by 2019, with TSD facilities increasing from 127 to 175 by 2023 (Figure 3.10). These registered treatment, storage, and disposal (TSD) facilities are designated locations where industrial and hazardous wastes are transported, stored, treated, recycled, or disposed of. The operationalization of the online Hazardous Waste Management System in 2020 has facilitated a more reliable platform for tracking hazardous waste volumes and movements. See Annex 3.F for the complete data on hazardous waste in the Philippines.

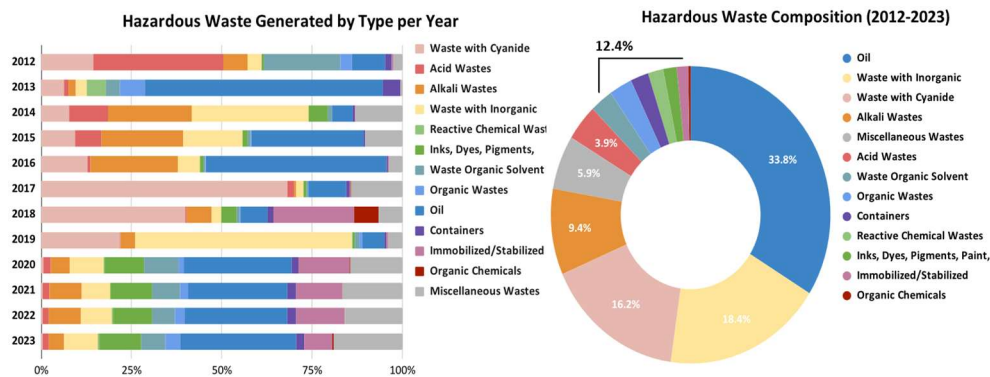


Figure 3.8. Composition of Hazardous Waste from 2012-2023. Data source: PSA, 2024

E-waste, formally categorized as "miscellaneous waste" under the Revised Procedures and Standards for the Management of Hazardous Waste (DAO, 2013-22), has rapidly grown in volume and significance in the Philippines. With rising consumer demand for electronics and short product lifecycles, e-waste generation is reported to be 4.7 kg per capita in 2022, making it one of the top generators in Southeast Asia (Baldé et al., 2025). With limited infrastructure for safe collection and treatment, informal recycling and disposal practices expose communities to hazardous substances, including lead, mercury, and brominated flame retardants.

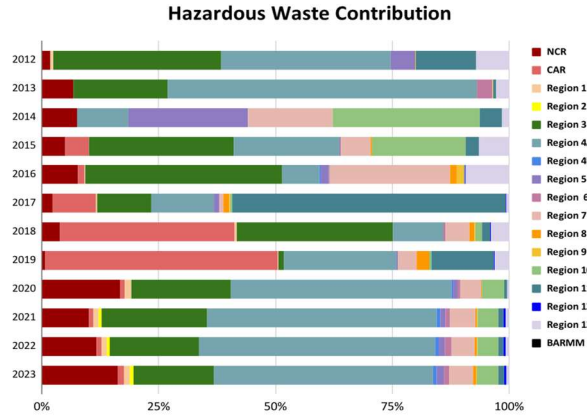


Figure 3.9. Contribution of Generated Hazardous Waste by Region from 2012-2023. Data source: PSA, 2024

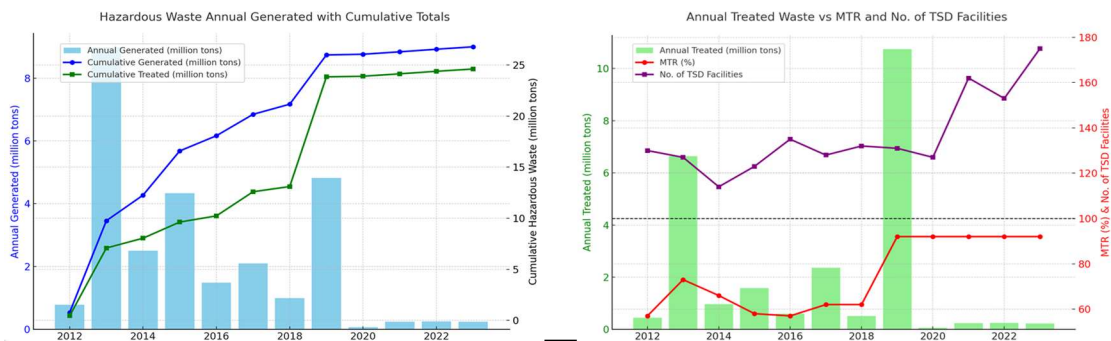


Figure 3.10. Hazardous waste generation and treatment trends in the Philippines, 2012–2023. Left panel: annual generated waste (bars) overlaid with cumulative generated and cumulative treated waste (lines). Right panel: annual treated waste (bars) overlaid with the multi-year treatment rate (MTR, %) and the number of treatments, storage, and disposal (TSD) facilities (lines) (PSA, 2024).

In addition to e-waste, other emerging hazardous waste streams should be examined as pointed out during the validation workshop (Annex 3.J). Their increasing volume in the coming decade underscores the need for early policy development, lifecycle management frameworks, and circular economy approaches for safe recovery and recycling. For example, end-of-life photovoltaic (PV) modules, batteries, and waste generated from renewable energy (RE) systems should also be examined, as these contain heavy metals, halogenated compounds, and complex composite materials that require specialized treatment and disposal pathways.

3.2.1.7 Oil Spills and Ship-Borne Pollution

The Philippines’ strategic location along major shipping routes makes it highly vulnerable to oil and sea-borne pollution. Between 2000 and 2021, 467 oil spills occurred: 14 major (>10,000 liters), 62 medium, 306 minor. NCR recorded the highest frequency (87 spills), followed by Region IV-A (64) (Alea et al, 2022). The highest volume of oil spilled was recorded in 2006 (2,118,500 liters), attributed mainly to the Guimaras oil spill incident (Figure 3.11).

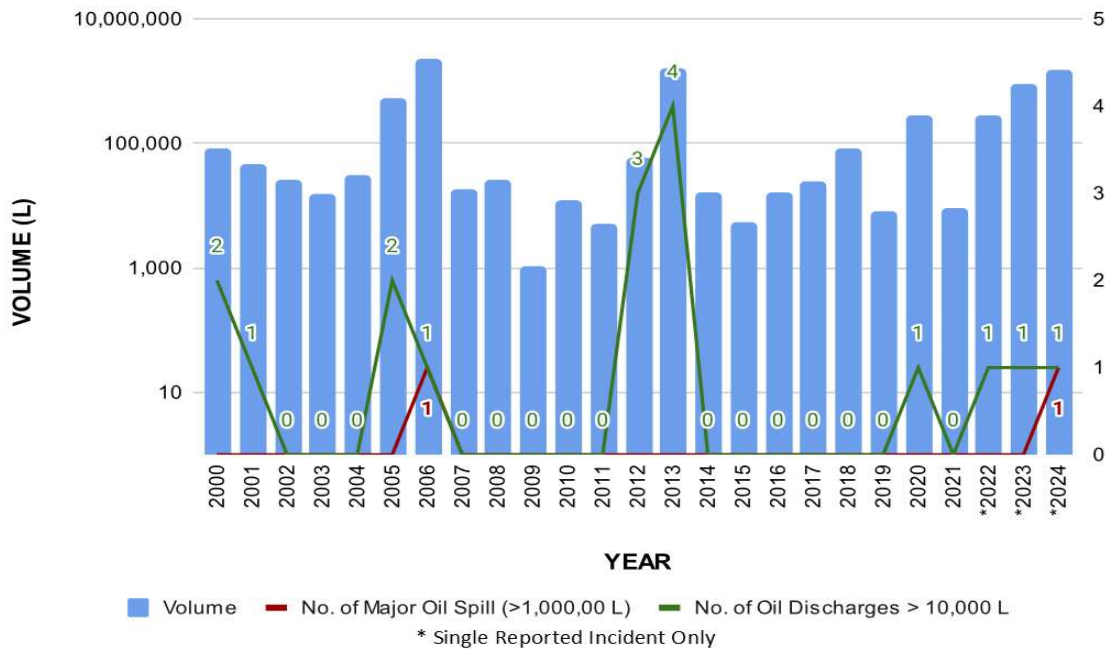


Figure 3.11. Total Volume of Recorded Oil Spill in the Philippines from 2000-2024. (Agaton et al., 2023; Alea et al., 2022; NDRRMC, 2024; Yuching, 2024)

Major incidents relevant to the SCS-LME (see Annex 3.G) include the 2000 Lingayen Gulf spill (57,000 liters), the 2013 Manila Bay pipeline leak (500,000 liters), and recent disasters: MT Princess Empress (800,000-900,000 liters, 2023) affecting Oriental Mindoro and Palawan's Verde Island (Agaton et al., 2023; Yuching, 2024), and MT Terra Nova (1,400,000-1,500,000 liters, 2024) capsizing in Manila Bay during Typhoon Gaemi, affecting Bataan, Bulacan, and Cavite fishing communities (NDRRMC, 2024). These disasters demonstrate the acute ecological and socio-economic impacts of oil pollution in bays and gulfs that drain into the South China Sea LME.

Ballast water discharge also poses another risk. Untreated ballast water introduces invasive species, microbes, and invertebrates across ecosystems (IMO, 2019). A notable case is the introduction of *Mytella strigata*, a mussel species native to South America, which was detected in Manila Bay between 2012 and 2014. The species has since spread to Lingayen Gulf, Aparri (Cagayan), and Batangas Port, disrupting local aquaculture (Vallejo, 2022).

3.2.1.8 Atmospheric Pollution and Deposition

Atmospheric pollution represents a significant yet often overlooked pathway of marine pollution, as airborne contaminants eventually settle into rivers, coasts, and the open ocean. Pollutants could be carried in the atmosphere, crossing watershed boundaries more easily than land-based discharges, making this pathway critical for transboundary ecosystems such as the South China Sea LME.

Point sources include coal-fired power plants and thousands of oil and gas generators, which release sulfur dioxide (SO₂), nitrogen oxides (NO_x), and particulate matter. Mobile sources, such as cars, trucks, and buses dominate urban emissions, accounting for approximately 60% of NO_x and 28% of SO₂. According to the 2021 National Emission Inventory, 56% of emissions originate from mobile sources, 35% from stationary sources, and 9% from diffuse “area sources” including construction, agricultural burning, and open solid waste burning (EMB, 2021b).

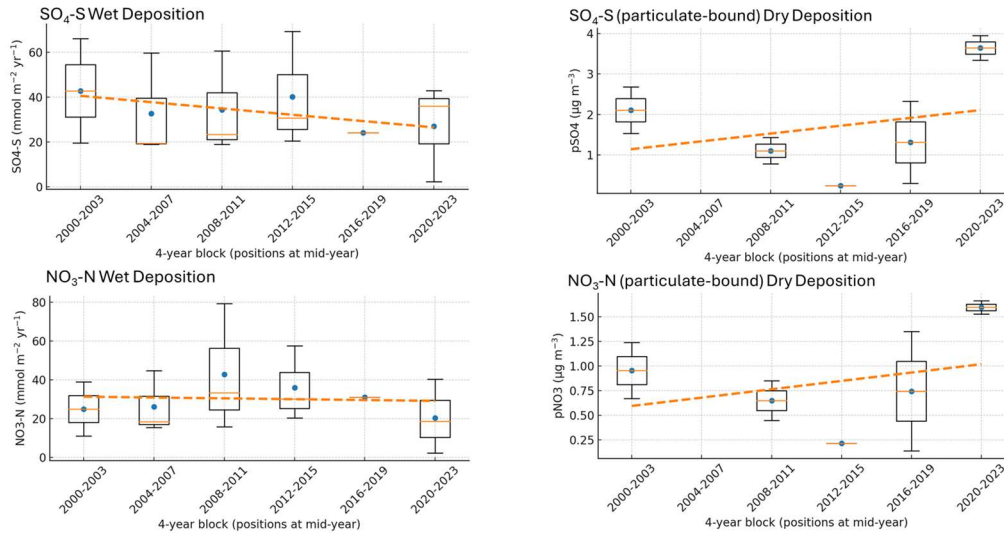


Figure 3.12. Trend analysis of wet deposition of SO_4 and NO_3 (left) and dry deposition of particulate-bound forms of SO_4 and NO_3 (right) (Network Center for EANET, 2025)

The Philippines is also part of the Acid Deposition Monitoring Network in East Asia, which provides long-term data on atmospheric deposition (Network Center for EANET, 2025). Figure 3.12 summarizes wet and dry deposition trends between 2000 and 2023, presented in four-year blocks. Wet deposition data show that sulfate-sulfur concentrations have declined slightly, reflecting the country’s gradual transition to cleaner fuels and stricter sulfur limits, especially in Metro Manila and CALABARZON. In contrast, nitrate-nitrogen levels fluctuate, with lowland sites such as Manila and Los Baños reporting increases during certain periods, likely linked to vehicle emissions, agricultural ammonia, and rainfall variability. See Annex 3.H for the reported data on wet and dry deposition, and their descriptive statistics.

Dry deposition results highlight particle-bound SO_2 and NO_x compounds as persistent stressors, with generally increasing trends. These pollutants either fall directly onto ocean surfaces or accumulate on land and are then washed into coastal waters during rainfall. Their combined effects include acidification, nutrient enrichment, and hypoxia. Although nitrogen deposition can initially stimulate productivity, it may also elevate CO_2 , reduce pH, and lower oxygen levels. These conditions stress coral reefs, mangroves, and fisheries across the South China Sea-Large Marine Ecosystem (LME).

3.2.2 Pollution Hotspots and Sensitive Areas

Several pollution hotspots along the Philippine coast of the South China Sea overlap with ecologically sensitive areas. Manila Bay is the most critical, with dense urbanization and industry producing high loads of coliform bacteria, nutrients, and solid waste. Its semi-enclosed character and limited tidal flushing trap pollutants, threatening fish nurseries and mangrove wetlands such as the Las Piñas–Parañaque Wetland Park. Health risks, fishery losses, and ecological degradation underscore the need for urgent remediation.

Lingayen Gulf is another hotspot where rivers such as the Agno and Dagupan carry sediments, nutrients, and contaminants (Deocadez et al., 2003). Sewage inputs from coastal towns, combined with upstream mining and logging, lead to increased turbidity and trace levels of mercury, cadmium, and lead. The gulf supports milkfish aquaculture, wild fisheries, and tourism (e.g., Hundred Islands National Park), making it highly vulnerable. Sewage and feed waste have triggered fish kills in aquaculture pens, while heavy metals in sediments pose a risk of bioaccumulation in seafood.

Batangas Bay and the Verde Island Passage (VIP) form a hotspot near refineries and power plants. Eastern Batangas Bay shows higher oil residues and heavy metal concentrations, whereas portions of the VIP, renowned as the “Amazon of the Oceans” for its biodiversity, are experiencing a decline in quality and trace metal pollution that could impair coral reefs and fisheries (Wagas & Andres, 2022). Likewise, even Palawan’s west coast, while less polluted, shows rising coliform counts. Recent environmental data provided by EMB regional offices were used to validate these initial findings (see Annex 3.J).

Collated data, though sparse and limited between 2000 and 2024, reinforces these hotspot patterns (Figure 3.13). Manila Bay shows elevated nutrients, coliform, and heavy metals (e.g., mercury, lead) with low DO levels, reflecting intense urban and industrial inputs (WEPA, 2025). Microplastics are also detected at elevated levels in the riverine discharge that drains to Manila Bay (Figure 3.13j). There is a growing threat of microplastic pollution at the Philippine waters of SCS-LME (Onda et al., 2024). In addition, persistent organic pollutants (POPS) such as polychlorinated biphenyls (PCBs) have been detected in plastic resin pellets (International Pellet Watch, 2025) found at Cavite City beaches and Manila Bay. These resins are industrial raw materials used to produce plastics that were unintentionally released to the environment.

On Palawan’s west coast, pressures are emerging near population and tourism centers. In Bacuit Bay (El Nido) and Coron Bay, fecal coliform levels frequently exceed standards due to inadequate sewage systems (Palawan Council for Sustainable Development [PCSD], 2023; Vicente, 2024). Nutrient enrichment poses a threat to adjacent reefs and seagrass beds. Moreover, the 200,000-ha Malampaya Sound Protected Area also receives marine litter inputs and could face risks from shipping and offshore gas operations (Coram et al., 2021; Haworth et al., 2024).

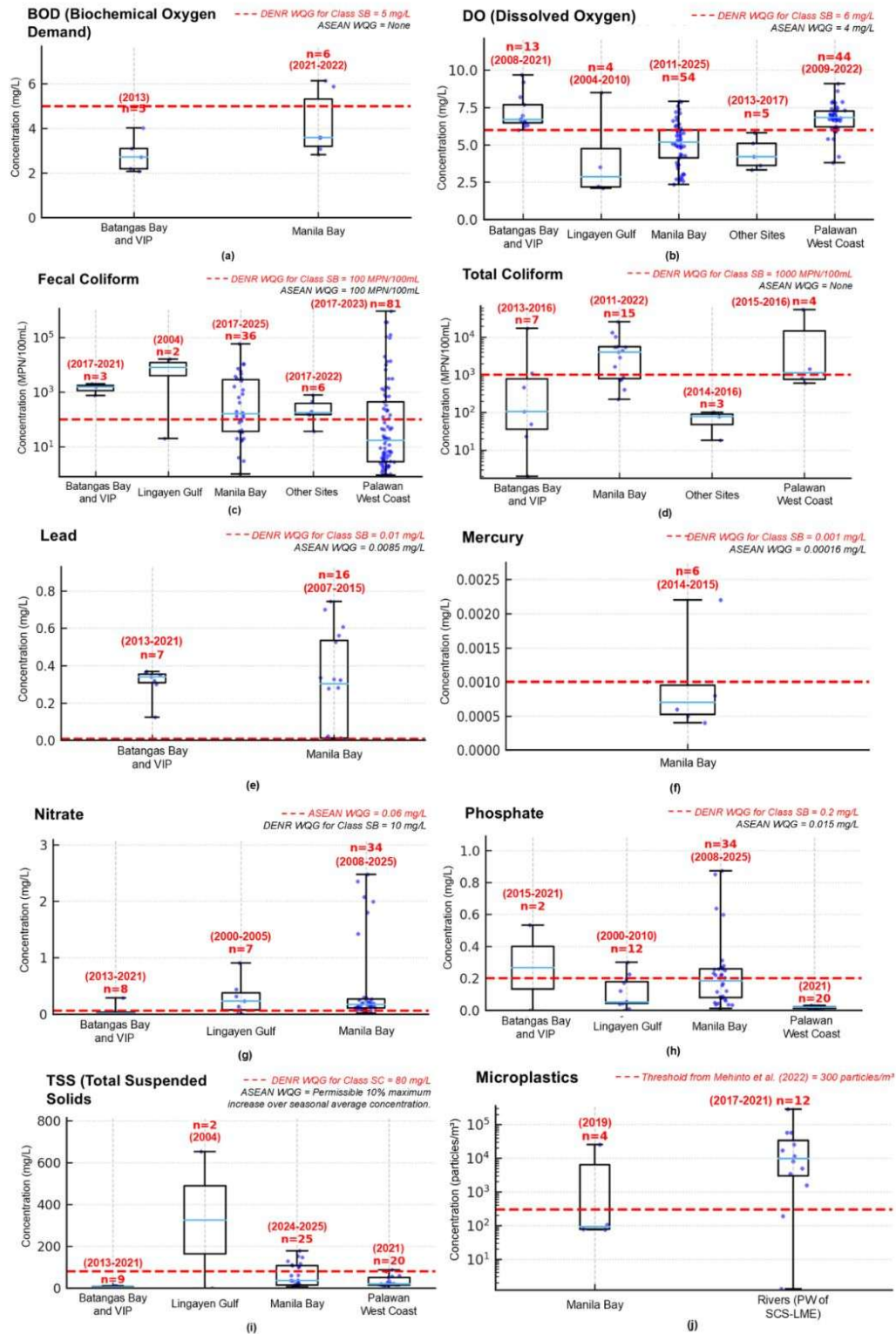


Figure 3.13. Box plot of measured concentrations of selected pollution indicators for coastal and estuarine water quality based on the compiled data (Annex 3.A) prior to the validation workshop. The box plot includes the number of datapoints (n) and temporal coverage, as well as the threshold for each water quality indicator.

3.3 Discussion and Conclusions

3.3.1 Priority Transboundary Pollution Issues

The South China Sea's interconnected oceanography creates transboundary pollution requiring multi-country collaboration:

- **Marine Plastic Debris:** Plastics drift across boundaries on ocean currents. Microplastics from the Mekong River reach the Philippines, which receives half of the Mekong-sourced particles stranded regionally (Nguyen et al., 2023). Philippine rivers contribute debris to Vietnam, Malaysia, and beyond, undermining marine life and tourism.
- **Oil Spills and Ship-Borne Pollution:** Heavy shipping traffic means spills spread across borders. Oil slicks drift to Vietnam, China, or Malaysia, depending on currents. Routine ship pollutants (bilge dumping, garbage, ballast water) have cumulative regional impacts. Joint preparedness under the ASEAN Oil Regional Spill Contingency Plan and the IMO conventions is vital.
- **Riverine Pollution and Nutrient Loading:** Rivers carry nutrients, sediment, and contaminants into shared waters. Philippine rivers (e.g., Pampanga, Agno) contribute to regional loadings. Nutrient plumes cause transboundary harmful algal blooms affecting multiple countries' fisheries. Mining siltation can smother distant coral reefs through sediment transport.
- **Shared Marine Resources Contamination:** Migratory species accumulate pollutants across regions. Microplastics, heavy metals, organometallic compounds, or persistent organic pollutants in Philippine waters could bioaccumulate in fish caught in the South China Sea LME. Conversely, pollutants released elsewhere contaminate Philippine seafood. Mercury, microplastics, POPs, and other emerging contaminants require monitoring, harmonized standards, and information exchange among regional partners.

Marine debris, oil pollution, nutrient enrichment, and toxic contaminants exemplify issues no country can address alone. These transboundary problems rank as priorities for regional cooperation and the Transboundary Diagnostic Analysis (TDA) of the South China Sea LME.

3.3.2 Impacts on Environment and Society

Pollution of coastal waters has wide-ranging environmental and societal impacts in the Philippines and across the South China Sea region. Degraded water quality undermines critical habitats. Coral reefs exposed to coastal acidification and eutrophication exhibit reduced coral cover and frequent algal overgrowth, as observed in the Lingayen Gulf (Isah et al., 2022). Seagrass beds and mangroves, vital fish nurseries, are smothered by silt and litter. In Manila Bay, remaining mangrove stands are choked with plastic waste, impairing ecological function. Biodiversity loss is evident, with declines in corals, while nutrient-driven red tides trigger mass mortality. Organic pollution load from sewage in semi-enclosed waters leads to hypoxia and periodic fish kills; Manila Bay has recorded such events alongside declining fisheries productivity. Chronic pollution also weakens ecosystem resilience to climate change, while extreme rainfall amplifies runoff of sediments and nutrients, fueling algal blooms and turbidity that further stress coral and seagrass ecosystems.

Societal impacts are equally severe. Public health is threatened as sewage contamination exposes beachgoers and coastal residents to pathogens, with extremely high coliform counts in Manila Bay and El Nido linked to gastroenteritis and other waterborne diseases. Seafood safety is at risk, as shellfish and fish accumulate bacteria and heavy metals, causing food poisoning or long-term health issues. Fisheries and aquaculture are compromised. In Dagupan (Lingayen Gulf), milkfish (bangus) ponds are affected by upstream waste discharges, which reduce the quality and prices of the fish (Stimson, 2023). Declining fish stocks and habitat degradation erode livelihoods, while smaller catches and fewer high-value species undermine incomes.

Tourism is also affected. Algal blooms, foul water, and trash-strewn beaches threaten destinations such as El Nido, where contamination has led to swimming bans. Pollution disproportionately affects poor coastal communities that rely heavily on natural resources. Informal settlers along estuaries and bays are highly vulnerable to pollution (health hazards) and its knock-on effects, such as the loss of fisheries and flooding from clogged waterways. Overall, degraded coastal waters erode ecosystem services, i.e., food, storm protection, and income, undermining the Philippines’ \$17 billion blue economy potential (ADB, 2025).

3.3.3 Risk Assessment

Pollution risks in Philippine coastal and marine habitats have intensified since the early 2000s, despite growing awareness and efforts to mitigate them. Rapid urbanization, industrialization, and tourism have driven pollutant loads beyond the capacity of existing infrastructure. In Metro Manila, population growth exacerbated the contamination of Manila Bay, with fecal coliform and nutrient levels remaining very poor throughout the 2000s. By 2018, parts of the bay were virtually unfit for recreation. Lingayen Gulf also faced siltation and heavy-metal contamination from mining and deforestation. Some improvements are evident. Fecal coliform levels in Manila Bay decreased from 126,000 MPN/100mL in 2019 to 51,300 in 2022 following rehabilitation efforts (Bautista, 2023). Batangas Bay’s integrated coastal management (ICM) under PEMSEA likewise contributes to improving conditions. Yet these gains remain fragile, as fish kills, HABS, and coral die-offs have become more frequent, amplified by climate stressors.

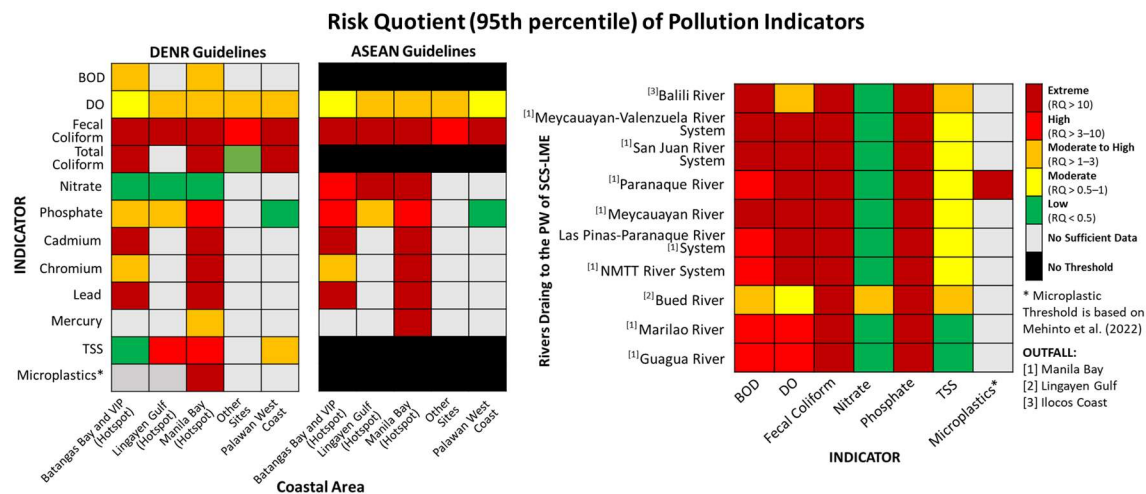


Figure 3.14. Left Panel: Heat Map for Coastal Hotspots in the Philippine Waters of SCS-LME (2000-2025). Right Panel: Heat Map for Rivers Draining to the Philippine Waters of SCS-LME (2000-2023). The DENR and ASEAN do not have established thresholds for microplastics; therefore, the threshold value was adopted from Mehinto et al. (2022). RQ was computed from the collated data of MEC prior to the validation workshop.

Figure 3.14 summarizes the risk quotient (RQ) analysis for a reasonable worst-case scenario using the DENR and ASEAN guidelines. Results show Manila Bay as the most critical hotspot, with phosphate, heavy metals, TSS, and coliforms exceeding thresholds, some in the Very High to Extreme risk bands (RQ >10 to >1000). Batangas Bay and Lingayen Gulf follow as secondary hotspots, while Palawan generally registers lower risks but still has localized exceedances. The ASEAN guidelines establish more conservative threshold values, resulting in most indicators across all sites being classified as high to extreme risk. See Annex 3.I for calculations and dataset on risk quotient analysis.

Rivers that are part of the watershed or river basin drainage to SCS-LME pose significant risks. Nitrate and TSS predominantly exhibit low to moderate risk levels. Dissolved oxygen (DO) levels indicate a moderate to high risk, with rivers in Metro Manila exhibiting extremely low DO concentrations. BOD risk levels vary considerably

across different locations. In contrast, phosphate, microplastics, and particularly fecal coliform contamination register alarmingly high to extreme risk levels. These findings highlight the impact of riverine pollution and the significant role of these rivers as a major conduit for land-based pollution into coastal waters.

Figure 3.15 presents the risk matrix for priority pollution scenarios. Five priority concerns emerged.

- Nutrient-driven eutrophication, HAB, and hypoxia (critical risk quadrant): already frequent, causing fish kills and ecosystem collapse in bays.
- Marine plastics crisis (critical risk quadrant): chronic, high-likelihood, transboundary threat undermining fisheries and tourism.
- Major oil spill (high risk quadrant): low-moderate frequency but catastrophic severity, given dense South China Sea shipping.
- Sewage-driven HAB and public health outbreaks (high risk quadrant): moderate-high frequency, high human and economic impact.
- Bioaccumulation of toxic contaminants (moderate-to-high risk quadrant): moderate severity and likelihood through bioaccumulation of heavy metals, POPs, and microplastics in the food chain, presenting long-term health and trade implications.

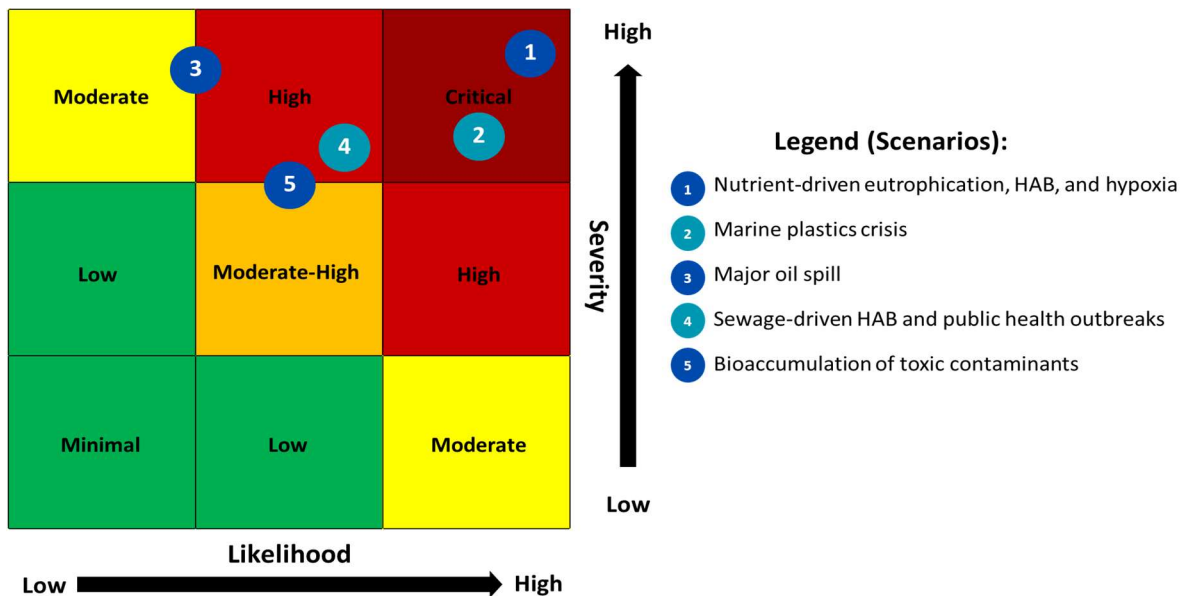


Figure 3.15. Risk Scenario Matrix

Without significant investment in wastewater and sanitation, as well as in nutrient and plastic management, high environmental and socio-economic risks are likely. Under such a “business-as-usual” scenario, persistent hypoxic zones in Manila Bay, as well as coastal habitats like coral reefs, would be under high threat from watershed-based pollution (Figure 3.16), resulting in biodiversity loss, and local fisheries decline. Climate change further compounds risks via heavier rainfall and flooding that flush pollutants into the sea.

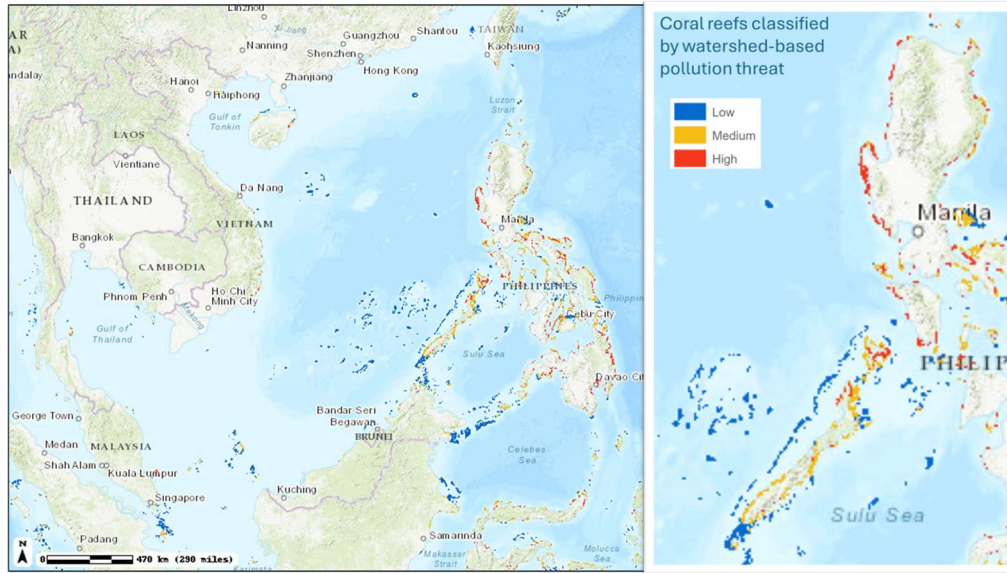


Figure 3.16. Coral reefs in the Philippine waters of the SCS-LME classified by watershed-based pollution threat (Burke, et al, 2011)

3.3.4 Current Management and Institutions

Marine pollution management in the Philippines involves multiple institutions across local, national, and regional levels. Key national frameworks include the Clean Water Act of 2004 and the Ecological Solid Waste Management Act of 2000, which are primarily implemented by the DENR-EMB, setting standards and monitoring protocols. While EMB guides the designation of Water Quality Management Areas, enforcement and infrastructure often lag. LGUs are frontline actors but face resource and capacity constraints, as seen in Manila and Dagupan, where sewage treatment remains limited. In Manila Bay, a Supreme Court Mandamus required 13 agencies to rehabilitate the bay and improve coordination, but also exposed overlapping mandates (Senate Economic Planning Office [SEPO], 2024). The Extended Producer Responsibility (EPR) Act of 2022 further strengthens plastic waste reduction by assigning producers responsibility for recovery and diversion, through compliance monitoring and integration with LGU systems remain evolving challenges.

High-profile cases highlight institutional gaps and responses driven by the institution. In Boracay (2018) and El Nido (2018–2023), closures and rehabilitation orders led to stricter enforcement of regulations on wastewater, establishment of treatment facilities, and monitoring of businesses, though low connection rates limit effectiveness (Fabro, 2018; PCSD, 2023). Civil society and universities also influence policy, e.g., studies on heavy metals in Batangas Bay prompted stricter oversight (Wagas & Andres, 2022). The Philippine Coast Guard has expanded its role in oil spill response and marine litter cleanup.

Regionally, the Philippines participates in PEMSEA’s SDS-SEA (Sustainable Development Strategy for Seas of East Asia), with Batangas Bay as a pilot for integrated coastal management, resulting in unified management plans and oil spill contingency measures (PEMSEA, 2006). The country also participates in ASEAN’s Regional Action Plan on Marine Debris (ASEAN, 2021), COBSEA’s nutrient management framework (COBSEA, 2024), and bilateral cooperation such as JOMSRE-SCS with Vietnam and the Sulu-Sulawesi Marine Ecoregion program (Supreme Court of the Philippines, 2002; Dang, 2021).

Overall, while a strong framework exists, efforts remain fragmented. Strengthening integration across levels and sectors, as well as enhancing regional collaboration, are essential for effective marine pollution governance.

3.3.5 Gaps and Priority Challenges

Despite ongoing efforts, significant gaps thus remain in addressing pollution in the Philippine coastal and marine waters. These represent priority challenges to overcome:

- **Infrastructure Gap:** Only a small percentage of coastal cities have sewage treatment facilities; proper MRFs and landfills are also lacking.
- **Enforcement and Capacity Building Gaps:** Weak monitoring, corruption, and insufficient technical capacity at the LGU level for pollution control and management.
- **Fragmented Effort of Institutions:** Weak and uncoordinated implementation of the inter-agencies' and LGUs' mandate.
- **Financial Constraints:** Limited sustained funding for infrastructure and monitoring.
- **Weak Transboundary Coordination and Cooperation:** There is no joint pollution contingency plan among SCS nations.
- **Limited Public Awareness:** Poor understanding of cumulative impacts and behavior change challenges.
- **Scientific and Data Gaps:** Incomplete data on emerging contaminants and insufficient long-term datasets. Inaccessibility of data to assess pollution sources from the industrial sector. Weak data governance on environmental data.

3.3.6 Recommended Priority Actions

A set of priority actions is recommended to tackle pollution crises in the Philippine waters (SCS-LME). The following actions should be pursued through coordinated national efforts and reinforced by regional cooperation:

- **Invest in Wastewater and Waste Management Infrastructure:** Accelerate construction of resource recovery facilities and treatment plants in major coastal cities, targeting 50% coverage by 2025, 100% by 2030. Implement sustainable financing schemes, public-private partnerships, circular resource-oriented sanitation (Promentilla et al., 2022), and nature-based solutions.
- **Strengthen Enforcement:** Expand real-time monitoring in hotspots, enforce heavier penalties, train enforcement units, and harmonize ASEAN standards.
- **Expand ICM and Watershed Management:** Replicate successful models across all hotspots, integrate upstream-downstream management (e.g., ridge-to-reef framework), and align sustainable agricultural and aquaculture practices.
- **Strengthen Regional Contingency Plan:** Develop protocols for mutual spill response, early warning systems, and operationalize ASEAN disaster response for marine pollution.
- **Strengthen Marine Litter Reduction Program:** Implement a ban on single-use plastics, improve collection rates, support recycling markets and circular economy innovations, and organize ASEAN Coastal Cleanup Day.
- **Enhance Protection of Sensitive Ecosystems for Climate Resilience:** Designate marine protected areas with high water quality, launch habitat restoration projects, and collaborate through regional initiatives.
- **Enhance National and Regional Coordination:** Establish and enact the appropriate national oceans policy, increase capacity-building funding, and promote joint research programs. Establish the South China Sea Watershed Partnership.
- **Strengthen Community, Capacity Building, Education, Participation, and Awareness (CEPA) programs:** Develop education campaigns, sustain positive behavioral changes from social and behavioral change communication (SBCC), community-based waste-to-resource recovery programs, involve fisherfolk in monitoring, and establish a civil society platform.

- **Advance Science, Data Governance, and Innovation:** Strengthen long-term monitoring of emerging contaminants, expand research on pollution impacts, promote open data governance, and invest in circular economy and pollution-control technologies. A need for the whole-of-society approach to harmonize standards and SOPs, interoperable data systems, consistent monitoring, and clearer cross-sectoral accountability.

3.4 Methodology and Analysis

This analysis adopted the TDA guidance document on pollution indicators, utilizing collated data from the 2000s to the 2020s (Annex 3.A). Sources included government agencies (DENR-EMB, PSA), regional bodies (World Bank, UNEP, PEMSEA), and peer-reviewed literature. Critical hotspots were identified based on the DENR EMB National Implementation Report on Land-based Pollution (2021). Analysis faced limitations from sparse spatial-temporal data coverage, methodological inconsistencies between monitoring programs, and attribution challenges in multi-stressor ecosystems. Results from data analysis should be interpreted with caution. Small sample sizes ($n < 5$), as seen in several sites (e.g., DO in Lingayen Gulf, mercury samples in Manila Bay), limit statistical reliability. High variability (e.g., BOD and fecal coliform in Manila Bay) reflects the influence of multiple pollution sources and variable sampling conditions. Median values alone may not fully capture the dynamics of pollution. Risk quotient analysis thus used reasonable worst-case scenarios (see Annex 3.I.) to evaluate pollution risks across sites and indicators. Where quantitative data were lacking, qualitative assessment and triangulation were employed. The methodology was also further strengthened through a multi-stakeholder validation workshop, which provided a review of datasets, clarified institutional mandates, identified emerging pollution issues, and helped verify hotspot selection and data limitations across source categories (see Annex 3.J).

Glossary

- **Acidification (Coastal/Marine)** - Decrease in pH of seawater due to CO₂ absorption and acidic inputs.
- **Agricultural Runoff / Diffuse Pollution** - Non-point source pollution from farmlands carrying nutrients, sediments, and pesticides.
- **Ammonia (NH₃-N)** - Un-ionized/ionized ammonia in water; toxic at elevated levels.
- **Antimicrobial Resistance (AMR)** – occurs when microorganisms has evolved to resist the effects of antimicrobial agents (e.g. drugs)
- **Aquaculture / Mariculture** - Cultivation of aquatic organisms in inland/coastal waters or marine environments.
- **ASEAN Regional Action Plan on Marine Debris** - ASEAN framework to reduce marine plastic pollution.
- **Atmospheric Deposition** - Transfer of pollutants from air to surface via wet or dry processes.
- **Ballast Water Discharge** - Release of water used to balance ships that may contain invasive species and pathogens.
- **Bioaccumulation** - Uptake and retention of substances in organisms over time.
- **Blue Economy** - Sustainable use of ocean resources for economic growth, livelihoods, and ecosystem health.
- **BOD (Biochemical Oxygen Demand)** - Amount of dissolved oxygen needed by microorganisms to break down organic matter in water over a specific period (commonly 5 days).
- **Box Plot** - Statistical chart showing distribution (median, quartiles, outliers).
- **Bureau of Fisheries and Aquatic Resources (BFAR)** - Fisheries policy and management bureau under the Department of Agriculture (DA).

- **Bureau of Soils and Water Management (BSWM)** - DA-attached agency on soil and water research and management.
- **Circular Economy** - Economic model prioritizing resource efficiency, reuse, and closed loops.
- **Clean Water Act (RA 9275)** - Philippine law providing water quality management framework.
- **Coastal Zone / Estuary** - Interface where rivers meet the sea with strong gradients and high productivity.
- **COBSEA (Coordinating Body on the Seas of East Asia)** - UNEP regional body coordinating marine environmental protection in E/SE Asia.
- **COD (Chemical Oxygen Demand)** - Amount of oxygen required to chemically oxidize organic and inorganic matter in water.
- **Coliform** – rod-shaped, gram-negative bacteria that are indicators of fecal and/or pathogenic contamination
- **Commission on Audit (COA)** - Independent constitutional body auditing government use of funds.
- **Contaminants** – physical, chemical, biological, or radiological substances found in the environment in higher concentrations than what is natural that eventually cause harm.
- **Corrosive** – materials that causes damage to other materials that comes into contact with it through chemical reaction.
- **Coral Reef** - Marine ecosystem built by calcifying corals; biodiversity hotspot sensitive to pollution.
- **Department of Environment and Natural Resources (DENR)** - Philippine agency for environment and natural resource governance.
- **Diffuse sediments** – sediments carried into a waterbody with no single identifiable source.
- **DO (Dissolved Oxygen)** - Concentration of oxygen dissolved in water available for aquatic life.
- **Domestic Wastewater / Sewage** - Household wastewater containing organics, nutrients, and pathogens.
- **Dry Deposition** - Direct settling/adsorption of particles and gases onto surfaces without precipitation.
- **EANET** - Regional network for acid deposition monitoring in East Asia.
- **Ecological Solid Waste Management Act (RA 9003)** - Philippine law mandating segregation, recycling, and proper waste facilities.
- **Emerging Contaminants** - Chemicals newly recognized as potential risks (e.g., PPCPs, PFAS) lacking comprehensive regulation.
- **Endocrine Disrupting Chemicals (EDCs) / Endocrine disruptors** - Substances that interfere with hormonal systems in organisms.
- **Environmental Governance** - Structures and processes for decision-making on environmental issues.
- **Environmental Management Bureau (EMB)** - DENR bureau responsible for pollution management and monitoring.
- **Eutrophication** - Nutrient enrichment of water bodies leading to excessive plant/algal growth and oxygen depletion.
- **E-waste (Electronic Waste)** - Discarded electrical/electronic devices and components.
- **Fecal Coliform (FC)** - Indicator bacteria originating from human/animal feces used to assess sanitary quality of water.
- **Fish Pens / Cages / Fishponds** - Aquaculture structures confining fish/shellfish for grow-out.
- **Harmful Algal Bloom (HAB)** - Algal proliferation that can produce toxins or cause ecological/human health impacts.

- **Hazardous Waste / Toxic Waste** - Wastes exhibiting hazardous characteristics (toxic, corrosive, ignitable, reactive).
- **Heat Map** - Visual display using color gradients to depict intensity/values across locations.
- **Heavy Metals** - Metals and metalloids toxic at low concentrations (e.g., Cd, Pb, Hg, Cr).
- **Hotspot (Pollution Hotspot)** - Location with elevated pollutant levels or acute impacts requiring priority action.
- **Hypoxia** - Condition of low dissolved oxygen that stresses or kills aquatic organisms.
- **Indicator / Pollution Indicator** - Measured variable representing a pollution pressure, state, or impact.
- **Industrial Effluent** - Wastewater discharged from industrial facilities.
- **Integrated Coastal Management (ICM)** - Process for coordinated management of coastal zones integrating sectors and stakeholders.
- **Invasive Species** - Non-native species whose introduction causes harm to environment, economy, or health.
- **Land-based Pollution** - Pollution originating from land activities transported to marine/coastal waters via rivers, runoff, or air.
- **Local Government Unit (LGU)** - Municipal, city, or provincial government unit with local environmental mandates.
- **Mangroves** - Intertidal forests providing nursery habitat and coastal protection.
- **Marine Litter / Marine Debris** - Solid material discarded or abandoned in the marine environment.
- **Marine protected area** – designated marine area by law and is governed by specific guidelines to manage activities, protect, and conserve the marine ecosystem in the area.
- **Material Recovery Facility (MRF)** - Facility for segregation, recycling, and processing of solid waste.
- **Metropolitan Waterworks and Sewerage System (MWSS)** - Regulator for water supply and wastewater services in Metro Manila.
- **Microplastics** - Plastic particles <5 mm from fragmentation or microbeads.
- **Mobile source** – moving vehicles, engines, and equipment that generates air pollution through combustion of fuels
- **Modeling Study / Modeled Data** - Results derived from computational models rather than direct measurements.
- **Nanoplastics** - Plastic particles <1 μm potentially more bioavailable and reactive.
- **Nature-Based Solutions (NbS)** - Actions inspired by ecosystems to address societal challenges and provide co-benefits.
- **Nitrate ($\text{NO}_3\text{-N}$)** - Oxidized form of nitrogen in water; key nutrient contributing to eutrophication.
- **Nitrogen Oxides (NO_x)** - Gases (NO , NO_2) from combustion contributing to ozone and nitrate formation.
- **Nonpoint source** – when an origin of pollutants is too broad or not identifiable.
- **Nutrient Load / Nutrient Flux** - Quantity of nutrients transported to a water body over time.
- **Oil Spill / Ship-borne Pollution** - Release of petroleum into the marine environment from accidents or operations.
- **Palawan Council for Sustainable Development (PCSD)** - Provincial body overseeing sustainable development and environment in Palawan.

- **Paralytic Shellfish Toxin (PST)** – neurotoxins released by microscopic algae that contaminates commercial shellfish.
- **Particulate Matter (PM)** - Airborne solid/liquid particles (e.g., PM10, PM2.5) affecting health and deposition.
- **Particulate Matter 2.5 (PM2.5)** – particles suspended in the air with diameters of 10 micrometers or smaller
- **Particulate Matter 10 (PM10)** - particles suspended in the air with diameters of 2.5 micrometers or smaller
- **Pathogens** - Disease-causing microorganisms (bacteria, viruses, protozoa) present in contaminated waters.
- **PEMSEA** - Partnerships in Environmental Management for the Seas of East Asia.
- **Persistent Organic Micropollutants** - Trace-level POP-like compounds persistent and bioactive at low concentrations.
- **Persistent Organic Pollutants (POPs)** - Toxic, bioaccumulative, and persistent chemicals subject to the Stockholm Convention.
- **PFAS (Per- and Polyfluoroalkyl Substances)** - Synthetic fluorinated chemicals resistant to degradation; linked to health risks.
- **Philippine Coast Guard (PCG)** - Maritime law enforcement and marine environmental protection agency.
- **Philippine Waters of the SCS-LME** - The portion of the SCS-LME within Philippine jurisdiction along the western seaboard.
- **Phosphate (PO₄-P)** - Orthophosphate concentration; a limiting nutrient that can drive algal blooms.
- **Plastic Leakage / Plastic Emission** - Escape of plastic waste from collection systems into the environment.
- **Pollution Load** - Mass of contaminants entering a water body per unit time.
- **Point source** – single, identifiable origin of pollution.
- **Public–Private Partnership (PPP)** - Cooperative arrangement between government and private sector for infrastructure/services.
- **Qualitative Assessment** - Non-numeric evaluation using expert judgment and triangulation.
- **Quantitative Assessment** - Numerical evaluation using measured or modeled data.
- **Reactive** – unstable materials that reacts violently with air or water, causing explosions.
- **Reasonable Worst-Case Scenario** - A conservative scenario using upper-bound concentrations to assess risk.
- **Regional Contingency Plan** - Cooperative protocol among states for emergency pollution response.
- **Resource-Oriented Sanitation** - Sanitation systems designed to recover water, nutrients, and energy.
- **Ridge-to-Reef Framework** - Integrated management approach linking uplands, rivers, and coasts.
- **Risk Band / Risk Matrix** - Categorization of risk by likelihood and consequence.
- **Risk Quotient (RQ)** - Ratio of measured concentration to guideline/threshold value to assess risk level.
- **Sanitary Landfill / Open Dumping** - Engineered facility for waste disposal vs. prohibited uncontrolled dumping.
- **Scenario Analysis** - Exploration of outcomes under different assumptions and interventions.
- **Seagrass** - Flowering marine plants forming coastal meadows essential for fisheries and carbon.
- **Sediment Load / Siltation** - Amount of eroded soil and particulate matter transported by water into aquatic systems.
- **Semi-enclosed Bay / Gulf** - Coastal water body with restricted exchange amplifying pollution impacts.

- **Sensitive Area / Critical Habitat** - Ecosystems highly vulnerable to pollution (e.g., reefs, seagrass, mangroves).
- **Solid Waste / Municipal Solid Waste (MSW)** - Garbage from households, commerce, institutions, and similar sources.
- **South China Sea Large Marine Ecosystem (SCS-LME)** - A high-biodiversity, semi-enclosed sea system shared by multiple countries, managed via LME approach.
- **Spatial–Temporal Coverage** - Extent of data across space and time used in analysis.
- **Stationary source** – nonmoving source of air pollution such as factories and power plants.
- **Strategic Action Programme (SAP)** - Agreed, policy-based regional program of actions addressing TDA-prioritized issues.
- **Submarine Groundwater Discharge (SGD)** - Flow of groundwater into the sea that can carry dissolved nutrients/contaminants.
- **Sulfur Dioxide (SO₂)** - Combustion-derived gas contributing to acid deposition.
- **Supreme Court Mandamus (Manila Bay Case)** - 2008 order directing 13 agencies to rehabilitate Manila Bay.
- **Sustainable Development Strategy for the Seas of East Asia (SDS-SEA)** - Regional strategy for sustainable coastal and ocean governance.
- **Threshold Value / Guideline Value** - Benchmark concentration used to evaluate water quality and ecological risk.
- **Transboundary Diagnostic Analysis (TDA)** - Analytical process identifying priority transboundary problems, their causes, and impacts.
- **Transboundary Pollution** - Pollution that crosses national or jurisdictional boundaries via air or water.
- **Treatment, Storage, and Disposal (TSD) Facility** - Authorized facility to manage hazardous wastes before final disposition.
- **Trend Analysis** - Statistical examination of changes in indicators over time.
- **Triangulation** - Cross-validation using multiple data sources/methods to increase confidence.
- **TSS (Total Suspended Solids)** - Particles suspended in water that can be trapped by a filter.
- **Turbidity** - Cloudiness or haziness of water caused by suspended particles.
- **Waste-to-Resource / Waste Valorization** - Conversion of wastes into valuable products or energy.
- **Water Quality Management Area (WQMA)** - Designated area for focused water quality management under RA 9275.
- **Watershed / River Basin** - Land area draining to a common outlet (river, bay, or gulf).
- **Wet Deposition** - Removal of pollutants via precipitation (rain, fog).

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1. **Michael Angelo B. Promentilla** - Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing, Supervision, Validation.
2. **Nicole Alexandra C. Aguila** – Data curation, Formal Analysis, Visualization, Writing – original draft, Writing – review & editing.

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Chapter 3 Annexes

Annex 3.A. Definition of Pollution Indicators

This annex provides the pollution category and its indicators used in this report. The table below summarizes the categories, parameters, and indicators included in the database that was used for data analysis.

Table 3.A.1. Key Pollution Indicators

Pollution Category	Parameter	Indicator
Marine and coastal water quality	Nutrient Pollution	Nitrate, Phosphate, Ammonia
	Organic Pollution	BOD, DO
	Coliform	Fecal, Total Coliform
	Heavy Metals	Cadmium, Chromium, Lead, Mercury
	Water Quality	TSS
	Contaminants of Emerging Concerns (CEC)	Microplastics
Aquaculture / mariculture pollution	Fish Kill Events	
	Shellfish Advisories	Harmful Algal Blooms (HABs)
Wastewater and industrial	Wastewater	Generated, Collected and Treated
	Treatment Facility	
	Pollution Load	Nitrate, Phosphate, BOD, COD, TSS, Fecal Coliform
Agricultural runoff	Fertilizer Use	N, P, K Fertilizer
	Pesticide Use	
	Nutrient Load	Nitrate, Phosphorus
Solid waste	Projected Generation	
	Disposal Facilities	
	Top Plastic-Emitting Rivers in the Philippines	Illegal Dumps, Sanitary Landfill, MRFs
Hazardous waste		Generated, Collected and Treated
		Waste with Cyanide, Acid Wastes, Alkali Wastes, Waste with Inorganic Chemicals, Reactive Chemical Wastes,
	Hazardous Waste	Inks/Dyes/Pigments/ Paint/Latex/Adhesives/ Organic Sludge, Waste Organic Solvent,
	Types of Hazardous Waste	Organic Wastes, Oil, Containers, Immobilized/Stabilized Wastes, Organic Chemicals, Miscellaneous Wastes
	Treatment Facility	
Oil pollution	Oil Spill	Major Incidents, Volume
Atmospheric pollution	Wet Deposition	Sulfate, Nitrate
	Dry Deposition	Sulfate (Particulate-bound), Nitrate (Particulate-bound)

The database in MS Excel contains several additional column parameters aside from the aforementioned ones. Key parameters include spatial characteristics (spatial resolution, region, spatial coverage, and specific site), temporal coverage (expressed in years), analytical values with corresponding units of measurement, and data sources. Additional attributes include limit of detection (LOD) values, environmental media classifications, waterbody class categories, relevance to Philippine Waters within the South China Sea Large Marine Ecosystem (SCS-LME), Predicted No Effect Concentration (PNEC) values and Risk Quotient calculations (based on DENR and ASEAN standards, see Annex 3.I.), and supplementary information. While these additional attributes are not required for all analyses, they may be essential for specific categories of pollution.

Coastal and Riverine Water Quality Indicators

This section presents statistical tables and box plot figures of water quality indicator concentration obtained from various data sources at identified pollution hotspots and rivers draining into the Philippine Waters of the SCS-LME. These statistical summaries provide insights into the concentration ranges, variability, and temporal coverage of key pollutants across sites. For detailed information on water quality thresholds, please check Annex 3.I.

Table 3.A.2. Summary Table for Number of Available Data on Water Quality by Pollution Hotspot.

Coastal Pollution Hotspots	BOD	DO	Fecal Coliform	Total Coliform	Cadmium	Chromium	Lead	Mercury	Nitrate	Phosphate	TSS	Micro-plastics
Batangas Bay and VIP (Hotspots)	5	13	3	7	1	1	7	0	8	2	9	0
Lingayen Gulf (Hotspot)	0	4	2	0	0	0	0	0	7	12	2	0
Manila Bay (Hotspot)	6	54	36	15	16	10	16	6	34	34	25	4
Other Sites	0	5	6	3	0	0	0	0	0	0	0	0
Palawan West Coast	0	44	81	4	0	0	0	0	0	20	20	0
Rivers (PW)	470	519	99	0	0	0	0	0	95	100	93	12

Table 3.A.3. Summary Table for Number of Available Data on Water Quality by Selected Rivers in the Philippines.

Rivers	BOD	DO	Fecal Coliform	Nitrate	Phosphate	TSS	Micro-plastics	Drains to Philippine Waters of SCS-LME?
Abra River	3	8	2	3	3	3	0	Yes
Agno River	13	19	3	2	3	3	0	Yes
Amburayan River	15	20	3	3	3	3	0	Yes
Angat River	11	14	3	3	3	3	0	Yes
Asin Gallano River	17	20	3	3	3	3	0	Yes
Atlag River	5	2	2	2	2	2	0	Yes
Balili River	15	20	3	2	3	3	0	No
Bocau River	21	23	3	2	3	3	0	Yes
Bued River	18	23	2	1	2	3	0	Yes
Cagayan River	15	21	3	3	3	3	0	Yes
Calao-Delinquent River System	2	0	0	0	0	0	0	Yes
Calapan River	17	19	3	2	3	3	0	Yes
Calumpang River	6	3	3	3	3	3	0	Yes
Canas River	11	12	3	3	3	3	3	Yes
Dagupan River	7	10	0	0	0	0	0	Yes
Diadi River System	2	0	0	0	0	0	0	No
Guagua River	10	11	3	3	3	3	0	No
Hagonoy River	5	3	3	3	3	3	0	Yes
Imus River	17	17	3	3	3	3	0	Yes
Labangan River	6	3	3	3	3	3	0	Yes
Las Pinas-Paranaque River System	3	3	3	3	3	1	0	Yes
Madlum River	3	1	1	1	1	1	0	Yes
Marikina River	13	8	0	0	0	0	0	Yes
Marilao River	21	22	3	3	3	3	0	Yes
Meycauayan River	21	22	3	3	3	3	2	Yes
Meycauayan-Valenzuela River System	10	12	3	2	2	1	0	Yes
Naguilian River System	4	1	1	1	1	1	0	Yes
NMTT River System	6	20	3	3	3	1	0	Yes
Obando River	13	14	3	3	3	3	0	Yes
Pampanga River	17	21	3	3	3	3	0	Yes
Pansipit River	13	13	3	3	3	3	0	Yes
Paranaque River	20	23	2	2	2	1	2	Yes

Pasig River	11	14	0	0	0	0	3	Yes
Pinacanauan de Tuguigarao	5	8	1	1	1	1	0	Yes
Pinamalayan River	5	2	2	2	2	2	0	Yes
Pugo River	5	0	2	2	2	2	0	Yes
Rio Grande River	10	11	3	3	3	3	0	Yes
San Juan River System	13	18	3	3	3	1	0	No
San Miguel River	3	1	1	1	1	1	0	No
Sinocalan River	1	1	0	0	0	0	0	Yes
Sinuculan-Dagupan River	7	8	1	1	1	1	0	Yes
Sta Maria River	17	19	3	3	3	3	0	Yes
Talisay River	13	13	2	3	3	3	0	Yes
Tullahan River	0	0	0	0	0	0	2	No
Upper Chico River	3	0	2	2	2	2	0	No
Ylang-Ylang River	17	16	3	3	3	3	0	Yes
Rivers (ALL)	470	519	99	95	100	93	12	

Table 3.A.4. Descriptive Statistics for Water Quality on Pollution Hotspots.

Coastal Pollution Hotspots	Indicator	unit	count	mean	std	median	p25	p75	p5	p95	min	max
Batangas Bay and VIP (Hotspots)	BOD	mg/L	5	2.8	0.79	2.7	2.2	3.1	2.1	3.8	2.1	4
Batangas Bay and VIP (Hotspots)	DO	mg/L	13	7.2	1.2	6.7	6.5	7.7	6.1	9.4	6	9.7
Batangas Bay and VIP (Hotspots)	Fecal Coliform	MPN/100mL	3	1400	640	1500	1100	1800	830	2000	750	2000
Batangas Bay and VIP (Hotspots)	Total Coliform	MPN/100mL	7	2700	6400	110	36	780	8.3	12000	2	17000
Batangas Bay and VIP (Hotspots)	Cadmium	mg/L	1	0.12		0.12	0.12	0.12	0.12	0.12	0.12	0.12
Batangas Bay and VIP (Hotspots)	Chromium	mg/L	1	0.065		0.065	0.065	0.065	0.065	0.065	0.065	0.065
Batangas Bay and VIP (Hotspots)	Lead	mg/L	7	0.31	0.085	0.34	0.31	0.36	0.18	0.37	0.13	0.37
Batangas Bay and VIP (Hotspots)	Nitrate	mg/L	8	0.049	0.098	0.015	0	0.033	0	0.2	0	0.29
Batangas Bay and VIP (Hotspots)	Phosphate	mg/L	2	0.27	0.38	0.27	0.13	0.4	0.027	0.51	0	0.53
Batangas Bay and VIP (Hotspots)	TSS	mg/L	9	6.4	3.4	7	5	7.8	1.6	11	1	11
Lingayen Gulf (Hotspot)	DO	mg/L	4	4.1	3	2.9	2.2	4.8	2.1	7.8	2.1	8.5

Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100mL	2	8000	11000	8000	4000	12000	820	15000	20	16000
Lingayen Gulf (Hotspot)	Nitrate	mg/L	7	0.29	0.31	0.23	0.074	0.38	0.0041	0.77	0	0.91
Lingayen Gulf (Hotspot)	Phosphate	mg/L	12	0.1	0.097	0.051	0.042	0.18	0.0052	0.26	0	0.3
Lingayen Gulf (Hotspot)	TSS	mg/L	2	330	460	330	160	490	33	620	0.5	650
Manila Bay (Hotspot)	BOD	mg/L	6	4.2	1.5	3.6	3.2	5.3	2.9	6.1	2.8	6.2
Manila Bay (Hotspot)	DO	mg/L	54	5.1	1.5	5.2	4.1	6	2.7	7.5	2.4	7.9
Manila Bay (Hotspot)	Fecal Coliform	MPN/100mL	36	3400	10000	160	36	2800	3.8	11000	1	60000
Manila Bay (Hotspot)	Total Coliform	MPN/100mL	15	5400	6700	4000	800	5500	350	17000	220	26000
Manila Bay (Hotspot)	Cadmium	mg/L	16	15	21	2.1	0.00078	39	0.00028	50	0.0002	57
Manila Bay (Hotspot)	Chromium	mg/L	10	0.26	0.26	0.28	0.032	0.32	0.01	0.66	0.01	0.89
Manila Bay (Hotspot)	Lead	mg/L	16	0.3	0.27	0.3	0.014	0.54	0.0083	0.71	0.0078	0.74
Manila Bay (Hotspot)	Mercury	mg/L	6	0.00092	0.00066	0.0007	0.00053	0.00095	0.00043	0.0019	0.0004	0.0022
Manila Bay (Hotspot)	Nitrate	mg/L	34	0.48	0.74	0.17	0.11	0.27	0.061	2.2	0.016	2.5
Manila Bay (Hotspot)	Phosphate	mg/L	34	0.22	0.22	0.18	0.079	0.26	0.035	0.71	0.011	0.87
Manila Bay (Hotspot)	TSS	mg/L	25	62	55	37	15	110	6.9	150	6	180
Manila Bay (Hotspot)	microplastics	pc/m3	4	6300	12000	91	77	6300	75	21000	75	25000
Other Sites	DO	mg/L	5	4.4	1	4.2	3.6	5.1	3.4	5.7	3.3	5.8
Other Sites	Fecal Coliform	MPN/100mL	6	300	270	180	150	390	64	700	36	780
Other Sites	Total Coliform	MPN/100mL	3	66	43	77	48	89	24	99	18	100
Palawan West Coast	DO	mg/L	44	6.8	0.97	6.8	6.2	7.3	5.4	7.9	3.8	9.1
Palawan West Coast	Fecal Coliform	MPN/100mL	81	26000	120000	17	2.9	440	0.9	110000	0.9	920000
Palawan West Coast	Total Coliform	MPN/100mL	4	14000	26000	1100	750	15000	630	46000	590	54000
Palawan West Coast	Phosphate	mg/L	20	0.017	0.0059	0.019	0.01	0.02	0.01	0.026	0.01	0.03

Palawan West Coast	TSS	mg/L	20	34	26	21	16	52	13	84	13	89
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Notes: std = Standard Deviation

p25 = 25th percentile of concentrations

p75 = 75th percentile of concentrations

p5 = 5th percentile of concentrations

p95 = 95th percentile of concentrations

MPN = Most Probable Number

Table 3.A.5. Descriptive Statistics for Water Quality on Selected Rivers in the Philippines.

Rivers	Indicator	unit	count	mean	std	median	p25	p75	p5	p95	min	max
Abra River	BOD	mg/L	3	1.2	0.19	1.2	1.1	1.3	1	1.3	0.98	1.4
Abra River	DO	mg/L	8	9	1.8	8.8	7.6	9.5	7.4	12	7.4	13
Abra River	Nitrate	mg/L	3	25	30	17	8.4	37	1.7	54	0.04	58
Abra River	Phosphate	mg/L	3	0.047	0.015	0.05	0.04	0.055	0.032	0.059	0.03	0.06
Abra River	TSS	mg/L	3	68	71	55	30	100	9.6	140	4.5	140
Abra River	Fecal Coliform	MPN/100mL	2	18000	19000	18000	11000	25000	5400	30000	4100	31000
Agno River	BOD	mg/L	13	2.6	2.1	1.3	1.2	2.3	1.1	6.7	1	6.9
Agno River	DO	mg/L	19	9.7	2.4	9.2	7.8	11	6.7	13	5.7	14
Agno River	Nitrate	mg/L	2	12	17	12	6.1	18	1.4	22	0.22	24
Agno River	Phosphate	mg/L	3	0.067	0.025	0.07	0.055	0.08	0.043	0.088	0.04	0.09
Agno River	TSS	mg/L	3	45	45	39	22	66	7.7	88	4.3	93
Agno River	Fecal Coliform	MPN/100mL	3	10000	9100	12000	6100	15000	1700	18000	540	18000
Amburayan River	BOD	mg/L	15	1.6	1.1	1.1	1	1.2	0.91	3.9	0.7	4.2
Amburayan River	DO	mg/L	20	9.4	1.7	9.2	8.3	10	7.4	12	7.1	14
Amburayan River	Nitrate	mg/L	3	6.5	7.2	4.1	2.5	9.3	1.1	14	0.8	15
Amburayan River	Phosphate	mg/L	3	0.04	0.01	0.04	0.035	0.045	0.031	0.049	0.03	0.05
Amburayan River	TSS	mg/L	3	14	4	13	12	16	11	18	11	19
Amburayan River	Fecal Coliform	MPN/100mL	3	77000	58000	99000	55000	110000	21000	120000	12000	120000
Angat River	BOD	mg/L	11	7.4	3.8	8.8	4.3	9.4	3.3	13	2.6	15
Angat River	DO	mg/L	14	4.9	0.98	4.8	4.1	5.6	3.8	6.3	3.6	7.1
Angat River	Nitrate	mg/L	3	0.66	0.39	0.69	0.48	0.87	0.3	1	0.26	1
Angat River	Phosphate	mg/L	3	0.17	0.046	0.16	0.15	0.19	0.13	0.21	0.13	0.22
Angat River	TSS	mg/L	3	23	12	16	16	26	15	35	15	37
Angat River	Fecal Coliform	MPN/100mL	3	22000	20000	29000	15000	34000	3100	37000	200	38000
Asin Gallano River	BOD	mg/L	17	1.4	0.69	1.1	1	1.1	0.98	2.5	0.9	3.4
Asin Gallano River	DO	mg/L	20	9.6	2.9	9.1	8.1	10	6.9	14	6.6	20
Asin Gallano River	Nitrate	mg/L	3	6.2	5.6	7.3	3.7	9.2	0.82	11	0.1	11
Asin Gallano River	Phosphate	mg/L	3	0.11	0.04	0.12	0.095	0.14	0.075	0.15	0.07	0.15
Asin Gallano River	TSS	mg/L	3	36	33	23	18	48	14	69	13	74
Asin Gallano River	Fecal Coliform	MPN/100mL	3	39000	26000	46000	28000	53000	14000	59000	9900	60000
Atlag River	BOD	mg/L	5	21	3.5	22	21	22	17	25	16	26
Atlag River	DO	mg/L	2	2.1	0.33	2.1	2	2.2	1.9	2.3	1.9	2.3
Atlag River	Nitrate	mg/L	2	0.24	0.028	0.24	0.23	0.25	0.22	0.26	0.22	0.26
Atlag River	Phosphate	mg/L	2	0.61	0.22	0.61	0.53	0.68	0.47	0.74	0.45	0.76
Atlag River	TSS	mg/L	2	32	14	32	27	37	23	41	22	42

Atlag River	Fecal Coliform	MPN/100mL	2	380000	110000	380000	340000	420000	310000	450000	300000	460000
Balili River	BOD	mg/L	15	39	18	37	29	47	12	66	7	72
Balili River	DO	mg/L	20	5.7	1.5	5.6	4.9	6.3	4.4	8.3	3.2	9.9
Balili River	Nitrate	mg/L	2	0.68	0	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Balili River	Phosphate	mg/L	3	1.2	0.52	1.2	0.95	1.5	0.73	1.7	0.68	1.7
Balili River	TSS	mg/L	3	38	34	19	19	48	18	71	18	77
Balili River	Fecal Coliform	MPN/100mL	3	1.5E+12	2E+12	4.2E+11	3.1E+11	2.1E+12	2.2E+11	3.5E+12	2E+11	3.8E+12
Bocaua River	BOD	mg/L	21	18	12	12	8.8	32	6.3	37	2.5	39
Bocaua River	DO	mg/L	23	3.5	2	2.6	2	5.4	1.5	6.7	1.1	7.9
Bocaua River	Nitrate	mg/L	2	0.82	0.15	0.82	0.76	0.87	0.72	0.91	0.71	0.92
Bocaua River	Phosphate	mg/L	3	2.4	0.99	2.8	2	2.9	1.4	3	1.2	3.1
Bocaua River	TSS	mg/L	3	34	8.5	38	31	39	25	39	24	40
Bocaua River	Fecal Coliform	MPN/100mL	3	520000	300000	650000	410000	690000	230000	730000	180000	740000
Bued River	BOD	mg/L	18	4.8	4.8	2.2	1.3	8.8	0.85	13	0	16
Bued River	DO	mg/L	23	8.1	2.1	8.5	7.7	9.3	6.4	10	0.05	11
Bued River	Nitrate	mg/L	1	7.9		7.9	7.9	7.9	7.9	7.9	7.9	7.9
Bued River	Phosphate	mg/L	2	0.53	0.15	0.53	0.47	0.58	0.43	0.62	0.42	0.63
Bued River	TSS	mg/L	3	130	10	130	120	130	120	140	120	140
Bued River	Fecal Coliform	MPN/100mL	2	1300000	17000	1300000	1300000	1300000	1300000	1300000	1300000	1300000
Cagayan River	BOD	mg/L	15	2.3	1.6	2	1.8	2.5	1	4.2	1	7.7
Cagayan River	DO	mg/L	21	7.4	0.78	7.2	6.9	7.9	6.4	8.2	6	9.4
Cagayan River	Nitrate	mg/L	3	0.18	0.081	0.23	0.16	0.23	0.1	0.23	0.09	0.23
Cagayan River	Phosphate	mg/L	3	0.083	0.0058	0.08	0.08	0.085	0.08	0.089	0.08	0.09
Cagayan River	TSS	mg/L	3	69	19	69	59	79	51	86	49	88
Cagayan River	Fecal Coliform	MPN/100mL	3	3700	1400	3700	3000	4400	2400	5000	2200	5100
Calao-Delinquente River System	BOD	mg/L	2	2.7	0.021	2.7	2.6	2.7	2.6	2.7	2.6	2.7
Calapan River	BOD	mg/L	17	9.1	4.1	9.3	5.6	11	4	16	3.8	17
Calapan River	DO	mg/L	19	2.4	0.89	2.6	1.8	3.1	1.2	3.4	0.9	4.3
Calapan River	Nitrate	mg/L	2	1.1	0.93	1.1	0.78	1.4	0.52	1.7	0.45	1.8
Calapan River	Phosphate	mg/L	3	0.4	0.13	0.45	0.35	0.47	0.27	0.49	0.25	0.49
Calapan River	TSS	mg/L	3	16	0.93	16	15	16	15	16	14	16
Calapan River	Fecal Coliform	MPN/100mL	3	78000	32000	89000	65000	96000	47000	100000	42000	100000
Calumpang River	BOD	mg/L	6	20	19	14	9.8	21	5.5	47	4.3	56
Calumpang River	DO	mg/L	3	4.2	1.7	5.1	3.6	5.2	2.5	5.2	2.2	5.2
Calumpang River	Nitrate	mg/L	3	1.2	0.67	0.98	0.86	1.5	0.76	1.9	0.73	2
Calumpang River	Phosphate	mg/L	3	1.6	0.77	1.5	1.2	2	1	2.4	0.95	2.5
Calumpang River	TSS	mg/L	3	30	6.7	34	28	34	24	34	22	34
Calumpang River	Fecal Coliform	MPN/100mL	3	20000	13000	15000	13000	25000	10000	33000	9900	35000
Canas River	BOD	mg/L	11	4.9	1.6	4.6	3.8	5.7	3	7.4	2.9	7.7
Canas River	DO	mg/L	12	6	0.53	6	5.5	6.4	5.4	6.8	5.3	7
Canas River	Nitrate	mg/L	3	1.5	0.51	1.2	1.2	1.6	1.1	2	1.1	2
Canas River	Phosphate	mg/L	3	1	0.28	1.1	0.9	1.2	0.75	1.2	0.71	1.3
Canas River	TSS	mg/L	3	66	14	65	59	73	54	79	53	81
Canas River	microplastics	pc/m3	3	99000	160000	7900	4700	150000	2200	260000	1600	290000

Canas River	Fecal Coliform	MPN/100mL	3	180000	33000	180000	160000	190000	140000	200000	140000	200000
Dagupan River	BOD	mg/L	7	6.1	1.9	6	5	7.7	3.8	8.2	3.3	8.4
Dagupan River	DO	mg/L	10	4.3	0.55	4.3	3.7	4.8	3.6	4.9	3.6	4.9
Diadi River System	BOD	mg/L	2	2.1	0.83	2.1	1.8	2.4	1.5	2.6	1.5	2.7
Guagua River	BOD	mg/L	10	24	14	24	16	30	5	43	1.6	51
Guagua River	DO	mg/L	11	3.1	1.3	3.1	2.4	3.7	1.4	5.2	1	5.7
Guagua River	Nitrate	mg/L	3	0.25	0.12	0.2	0.19	0.3	0.17	0.37	0.17	0.39
Guagua River	Phosphate	mg/L	3	1.3	0.23	1.2	1.2	1.4	1.2	1.6	1.2	1.6
Guagua River	TSS	mg/L	3	33	7.2	37	31	37	26	38	25	38
Guagua River	Fecal Coliform	MPN/100mL	3	750000	400000	950000	620000	980000	360000	1000000	290000	1000000
Hagonoy River	BOD	mg/L	5	15	8.1	13	9.6	19	8.3	26	8	28
Hagonoy River	DO	mg/L	3	3.2	0.89	3.4	2.8	3.7	2.3	3.9	2.2	3.9
Hagonoy River	Nitrate	mg/L	3	0.45	0.081	0.44	0.41	0.49	0.39	0.53	0.38	0.54
Hagonoy River	Phosphate	mg/L	3	0.28	0.044	0.3	0.27	0.31	0.24	0.31	0.23	0.31
Hagonoy River	TSS	mg/L	3	45	4.2	43	42	46	42	49	42	49
Hagonoy River	Fecal Coliform	MPN/100mL	3	120000	60000	110000	92000	150000	79000	180000	75000	190000
Imus River	BOD	mg/L	17	11	3.2	10	9.5	12	7.1	16	5.7	19
Imus River	DO	mg/L	17	5.5	2.2	5.2	4.7	5.7	3.9	7.5	3	14
Imus River	Nitrate	mg/L	3	1.4	0.34	1.2	1.2	1.5	1.2	1.7	1.2	1.8
Imus River	Phosphate	mg/L	3	1.5	0.065	1.5	1.5	1.6	1.5	1.6	1.5	1.6
Imus River	TSS	mg/L	3	76	47	54	49	92	45	120	44	130
Imus River	Fecal Coliform	MPN/100mL	3	480000	310000	470000	320000	630000	210000	760000	180000	800000
Labangan River	BOD	mg/L	6	12	4.1	12	8.8	14	7.5	17	7.3	18
Labangan River	DO	mg/L	3	3.4	0.81	3.3	3	3.8	2.7	4.2	2.7	4.3
Labangan River	Nitrate	mg/L	3	0.38	0.08	0.38	0.34	0.42	0.31	0.45	0.3	0.46
Labangan River	Phosphate	mg/L	3	0.28	0.11	0.22	0.22	0.31	0.21	0.38	0.21	0.4
Labangan River	TSS	mg/L	3	36	16	31	27	42	24	51	24	54
Labangan River	Fecal Coliform	MPN/100mL	3	56000	31000	66000	44000	74000	26000	80000	22000	82000
Las Pinas-Paranaque River System	BOD	mg/L	3	49	10	43	42	52	42	59	42	61
Las Pinas-Paranaque River System	DO	mg/L	3	0.29	0.33	0.13	0.11	0.4	0.085	0.62	0.08	0.67
Las Pinas-Paranaque River System	Nitrate	mg/L	3	0.3	0.12	0.29	0.24	0.36	0.2	0.41	0.19	0.42
Las Pinas-Paranaque River System	Phosphate	mg/L	3	2.1	0.28	2.3	2	2.3	1.8	2.3	1.8	2.3
Las Pinas-Paranaque River System	TSS	mg/L	1	55		55	55	55	55	55	55	55
Las Pinas-Paranaque River System	Fecal Coliform	MPN/100mL	3	3900000	1500000	4300000	3200000	4700000	2400000	5000000	2100000	5100000
Madlum River	BOD	mg/L	3	3.6	0.8	3.2	3.2	3.9	3.1	4.4	3.1	4.6
Madlum River	DO	mg/L	1	7.1		7.1	7.1	7.1	7.1	7.1	7.1	7.1
Madlum River	Nitrate	mg/L	1	0.24		0.24	0.24	0.24	0.24	0.24	0.24	0.24
Madlum River	Phosphate	mg/L	1	0.07		0.07	0.07	0.07	0.07	0.07	0.07	0.07
Madlum River	TSS	mg/L	1	18		18	18	18	18	18	18	18
Madlum River	Fecal Coliform	MPN/100mL	1	11000		11000	11000	11000	11000	11000	11000	11000
Marikina River	BOD	mg/L	13	25	8.1	25	18	29	14	36	12	42
Marikina River	DO	mg/L	8	3.4	0.96	3.5	2.9	3.8	2.2	4.7	2.2	5
Marilao River	BOD	mg/L	21	30	11	29	23	39	11	45	8.2	52
Marilao River	DO	mg/L	22	2.3	1.2	2.1	1.6	2.5	0.97	4.9	0.8	5.4

Marilao River	Nitrate	mg/L	3	0.44	0.11	0.47	0.39	0.5	0.33	0.52	0.31	0.53
Marilao River	Phosphate	mg/L	3	1.7	0.38	1.8	1.5	1.9	1.3	1.9	1.2	1.9
Marilao River	TSS	mg/L	3	32	8.7	33	28	37	24	40	23	41
Marilao River	Fecal Coliform	MPN/100mL	3	2000000	400000	1900000	1800000	2200000	1700000	2400000	1700000	2500000
Meycauayan River	BOD	mg/L	21	67	27	59	49	85	38	120	36	140
Meycauayan River	DO	mg/L	22	1.7	1.7	1.2	0.8	2.2	0.45	5	0.05	6.9
Meycauayan River	Nitrate	mg/L	3	0.27	0.13	0.23	0.2	0.33	0.18	0.4	0.17	0.42
Meycauayan River	Phosphate	mg/L	3	1.8	0.21	1.8	1.7	1.9	1.6	1.9	1.5	1.9
Meycauayan River	TSS	mg/L	3	30	2.1	31	30	32	28	32	28	32
Meycauayan River	microplastics	pc/m3	2	29000	41000	29000	15000	43000	3100	55000	190	58000
Meycauayan River	Fecal Coliform	MPN/100mL	3	29000000	40000000	5900000	5900000	40000000	5900000	68000000	5900000	74000000
Meycauayan-Valenzuela River System	BOD	mg/L	10	64	14	67	59	76	42	77	40	78
Meycauayan-Valenzuela River System	DO	mg/L	12	1.2	1.2	0.85	0.43	1.5	0.078	3.3	0.05	3.8
Meycauayan-Valenzuela River System	Nitrate	mg/L	2	0.23	0.22	0.23	0.15	0.3	0.086	0.36	0.07	0.38
Meycauayan-Valenzuela River System	Phosphate	mg/L	2	1.9	0.74	1.9	1.6	2.2	1.4	2.4	1.4	2.4
Meycauayan-Valenzuela River System	TSS	mg/L	1	47		47	47	47	47	47	47	47
Meycauayan-Valenzuela River System	Fecal Coliform	MPN/100mL	3	89000000	100000000	35000000	29000000	120000000	24000000	190000000	22000000	210000000
Naguilian River System	BOD	mg/L	4	2.6	0.92	2.2	2.1	2.7	2	3.7	2	4
Naguilian River System	DO	mg/L	1	9.3		9.3	9.3	9.3	9.3	9.3	9.3	9.3
Naguilian River System	Nitrate	mg/L	1	0.43		0.43	0.43	0.43	0.43	0.43	0.43	0.43
Naguilian River System	Phosphate	mg/L	1	0.09		0.09	0.09	0.09	0.09	0.09	0.09	0.09
Naguilian River System	TSS	mg/L	1	16		16	16	16	16	16	16	16
Naguilian River System	Fecal Coliform	MPN/100mL	1	3200		3200	3200	3200	3200	3200	3200	3200
NMTT River System	BOD	mg/L	6	42	5.9	42	38	46	35	49	34	49
NMTT River System	DO	mg/L	20	1.6	1.2	1.8	0.4	2.4	0.05	3.4	0.05	3.6
NMTT River System	Nitrate	mg/L	3	0.56	0.4	0.44	0.34	0.72	0.25	0.94	0.23	1
NMTT River System	Phosphate	mg/L	3	1.5	0.24	1.4	1.4	1.6	1.4	1.8	1.4	1.8
NMTT River System	TSS	mg/L	1	51		51	51	51	51	51	51	51
NMTT River System	Fecal Coliform	MPN/100mL	3	31000000	18000000	34000000	22000000	41000000	13000000	46000000	11000000	47000000
Obando River	BOD	mg/L	13	36	37	31	16	36	11	85	9.8	150
Obando River	DO	mg/L	14	3	1.1	2.9	2.5	3.7	1.4	4.7	1.3	5.2
Obando River	Nitrate	mg/L	3	0.28	0.13	0.29	0.22	0.35	0.16	0.39	0.15	0.4
Obando River	Phosphate	mg/L	3	2	2.1	0.73	0.73	2.6	0.73	4.1	0.73	4.5
Obando River	TSS	mg/L	3	27	2.8	28	26	29	25	30	24	30
Obando River	Fecal Coliform	MPN/100mL	3	220000	180000	140000	120000	290000	110000	400000	100000	430000
Pampanga River	BOD	mg/L	17	11	12	9.4	4	13	2	30	1.8	52
Pampanga River	DO	mg/L	21	5.1	1.2	5.4	4.3	5.9	3.4	7	3	7.2
Pampanga River	Nitrate	mg/L	3	0.72	0.37	0.66	0.53	0.89	0.42	1.1	0.39	1.1
Pampanga River	Phosphate	mg/L	3	0.23	0.04	0.25	0.22	0.25	0.19	0.25	0.18	0.25
Pampanga River	TSS	mg/L	3	53	14	53	46	60	40	65	39	67
Pampanga River	Fecal Coliform	MPN/100mL	3	24000	3800	22000	21000	25000	21000	27000	20000	28000
Pansipit River	BOD	mg/L	13	2.9	1.5	2.3	1.7	4	1.2	5.1	1.2	5.7
Pansipit River	DO	mg/L	13	6.5	1.3	6.7	6.2	7.4	4.5	7.9	4.1	8.5
Pansipit River	Nitrate	mg/L	3	0.43	0.075	0.43	0.39	0.47	0.36	0.49	0.35	0.5

Pansipit River	Phosphate	mg/L	3	0.72	0.075	0.72	0.69	0.76	0.66	0.79	0.65	0.8
Pansipit River	TSS	mg/L	3	21	6.8	22	18	24	14	26	13	27
Pansipit River	Fecal Coliform	MPN/100mL	3	2000	1900	1400	980	2800	640	3800	550	4100
Paranaque River	BOD	mg/L	20	46	9.5	43	39	55	29	59	29	61
Paranaque River	DO	mg/L	23	1.1	1	0.9	0.1	1.7	0.05	3	0.05	3.3
Paranaque River	Nitrate	mg/L	2	0.54	0.16	0.54	0.48	0.59	0.43	0.64	0.42	0.65
Paranaque River	Phosphate	mg/L	2	1.6	1.6	1.6	0.99	2.1	0.53	2.6	0.42	2.7
Paranaque River	TSS	mg/L	1	47		47	47	47	47	47	47	47
Paranaque River	microplastics	pc/m3	2	15000	14000	15000	10000	20000	6000	24000	5000	25000
Paranaque River	Fecal Coliform	MPN/100mL	2	6100000	16000000	6100000	5500000	66000000	5100000	71000000	4900000	7200000
Pasig River	BOD	mg/L	11	32	19	24	16	54	12	56	11	57
Pasig River	DO	mg/L	14	3.1	0.89	3	2.3	3.4	2.2	4.8	2.1	4.9
Pasig River	microplastics	pc/m3	3	6800	9000	3400	1700	10000	340	16000	1.3	17000
Pinacanauan de Tuguigarao	BOD	mg/L	5	1.2	0.18	1.1	1.1	1.2	1.1	1.4	1.1	1.5
Pinacanauan de Tuguigarao	DO	mg/L	8	8.9	2.8	8.1	7.5	9.7	6.1	13	5.6	15
Pinacanauan de Tuguigarao	Nitrate	mg/L	1	0.12		0.12	0.12	0.12	0.12	0.12	0.12	0.12
Pinacanauan de Tuguigarao	Phosphate	mg/L	1	0.04		0.04	0.04	0.04	0.04	0.04	0.04	0.04
Pinacanauan de Tuguigarao	TSS	mg/L	1	8.1		8.1	8.1	8.1	8.1	8.1	8.1	8.1
Pinacanauan de Tuguigarao	Fecal Coliform	MPN/100mL	1	200		200	200	200	200	200	200	200
Pinamalayan River	BOD	mg/L	5	7.1	3.9	4.9	4.4	9.5	3.9	12	3.8	13
Pinamalayan River	DO	mg/L	2	4.4	0.88	4.4	4.1	4.7	3.8	4.9	3.8	5
Pinamalayan River	Nitrate	mg/L	2	0.51	0.24	0.51	0.43	0.6	0.36	0.66	0.34	0.68
Pinamalayan River	Phosphate	mg/L	2	0.13	0.014	0.13	0.13	0.14	0.12	0.14	0.12	0.14
Pinamalayan River	TSS	mg/L	2	16	0.31	16	16	17	16	17	16	17
Pinamalayan River	Fecal Coliform	MPN/100mL	2	14000	16000	14000	8800	20000	4300	25000	3100	26000
Pugo River	BOD	mg/L	5	0.95	0.04	0.95	0.93	0.98	0.91	1	0.9	1
Pugo River	Nitrate	mg/L	2	4.8	4.7	4.8	3.1	6.4	1.8	7.8	1.5	8.1
Pugo River	Phosphate	mg/L	2	0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pugo River	TSS	mg/L	2	7	4.2	7	5.5	8.5	4.3	9.7	4	10
Pugo River	Fecal Coliform	MPN/100mL	2	13000	15000	13000	8000	19000	3600	23000	2500	24000
Rio Grande River	BOD	mg/L	10	6	1.8	5.9	4.8	7	3.7	8.7	3.7	9.6
Rio Grande River	DO	mg/L	11	5.9	0.66	6.1	5.6	6.5	4.9	6.6	4.5	6.6
Rio Grande River	Nitrate	mg/L	3	2.3	0.84	2.2	1.8	2.7	1.6	3.1	1.5	3.2
Rio Grande River	Phosphate	mg/L	3	0.99	0.16	1	0.93	1.1	0.84	1.1	0.82	1.1
Rio Grande River	TSS	mg/L	3	51	14	55	45	59	37	62	35	63
Rio Grande River	Fecal Coliform	MPN/100mL	3	150000	53000	130000	120000	170000	110000	200000	100000	210000
San Juan River System	BOD	mg/L	13	54	14	55	44	67	33	71	33	74
San Juan River System	DO	mg/L	18	1.4	1.1	1.4	0.2	2.4	0.05	3	0.05	3.1
San Juan River System	Nitrate	mg/L	3	0.2	0.11	0.18	0.15	0.25	0.12	0.31	0.11	0.32
San Juan River System	Phosphate	mg/L	3	2.3	0.11	2.3	2.3	2.4	2.2	2.4	2.2	2.4
San Juan River System	TSS	mg/L	1	45		45	45	45	45	45	45	45
San Juan River System	Fecal Coliform	MPN/100mL	3	7600000	50000000	7100000	5000000	10000000	3300000	12000000	2900000	1300000
San Miguel River	BOD	mg/L	3	6.7	3.2	6.4	5	8.2	3.9	9.6	3.7	10
San Miguel River	DO	mg/L	1	5.8		5.8	5.8	5.8	5.8	5.8	5.8	5.8

San Miguel River	Nitrate	mg/L	1	0.45		0.45	0.45	0.45	0.45	0.45	0.45	0.45
San Miguel River	Phosphate	mg/L	1	0.17		0.17	0.17	0.17	0.17	0.17	0.17	0.17
San Miguel River	TSS	mg/L	1	62		62	62	62	62	62	62	62
San Miguel River	Fecal Coliform	MPN/100mL	1	110000		110000	110000	110000	110000	110000	110000	110000
Sinocalan River	BOD	mg/L	1	2.2		2.2	2.2	2.2	2.2	2.2	2.2	2.2
Sinocalan River	DO	mg/L	1	5.8		5.8	5.8	5.8	5.8	5.8	5.8	5.8
Sinuculan-Dagupan River	BOD	mg/L	7	6.1	3.2	4.3	4.2	7	3.8	11	3.8	12
Sinuculan-Dagupan River	DO	mg/L	8	5.8	0.57	5.7	5.3	6.1	5.2	6.7	5.2	6.8
Sinuculan-Dagupan River	Nitrate	mg/L	1	0.46		0.46	0.46	0.46	0.46	0.46	0.46	0.46
Sinuculan-Dagupan River	Phosphate	mg/L	1	0.41		0.41	0.41	0.41	0.41	0.41	0.41	0.41
Sinuculan-Dagupan River	TSS	mg/L	1	18		18	18	18	18	18	18	18
Sinuculan-Dagupan River	Fecal Coliform	MPN/100mL	1	8700		8700	8700	8700	8700	8700	8700	8700
Sta Maria River	BOD	mg/L	17	20	11	15	12	26	7.7	37	7.4	47
Sta Maria River	DO	mg/L	19	3.3	1.4	2.9	2.5	4.1	1.8	5.2	1.3	6.7
Sta Maria River	Nitrate	mg/L	3	0.76	0.38	0.79	0.58	0.96	0.41	1.1	0.37	1.1
Sta Maria River	Phosphate	mg/L	3	2.5	1.6	2	1.6	3.2	1.3	4.1	1.2	4.4
Sta Maria River	TSS	mg/L	3	26	3.5	26	24	28	23	29	22	29
Sta Maria River	Fecal Coliform	MPN/100mL	3	440000	460000	240000	180000	600000	130000	890000	120000	960000
Talisay River	BOD	mg/L	13	5.9	3	5.7	4	6.6	2.1	11	2	12
Talisay River	DO	mg/L	13	5.2	1.2	5.3	4.2	6.3	3.6	6.7	3.4	6.7
Talisay River	Nitrate	mg/L	3	0.37	0.096	0.35	0.32	0.41	0.29	0.46	0.28	0.47
Talisay River	Phosphate	mg/L	3	0.12	0.0058	0.12	0.12	0.12	0.11	0.12	0.11	0.12
Talisay River	TSS	mg/L	3	25	6.4	22	22	27	21	32	21	33
Talisay River	Fecal Coliform	MPN/100mL	2	93000	18000	93000	86000	99000	81000	100000	80000	110000
Tullahan River	microplastics	pc/m3	2	34000	32000	34000	23000	46000	14000	55000	11000	57000
Upper Chico River	BOD	mg/L	3	1.2	0.25	1.1	1.1	1.3	1	1.5	1	1.5
Upper Chico River	Nitrate	mg/L	2	17	24	17	8.4	25	1.7	32	0.04	33
Upper Chico River	Phosphate	mg/L	2	0.05	0.014	0.05	0.045	0.055	0.041	0.059	0.04	0.06
Upper Chico River	TSS	mg/L	2	21	10	21	18	25	15	28	14	28
Upper Chico River	Fecal Coliform	MPN/100mL	2	15000	8100	15000	12000	18000	9600	20000	9000	20000
Ylang-Ylang River	BOD	mg/L	17	40	44	23	8.3	64	5.2	120	4.9	130
Ylang-Ylang River	DO	mg/L	16	5	0.66	4.9	4.6	5.4	4.1	6.1	4	6.2
Ylang-Ylang River	Nitrate	mg/L	3	1.8	0.43	1.6	1.5	1.9	1.5	2.2	1.5	2.3
Ylang-Ylang River	Phosphate	mg/L	3	1.3	0.44	1	1	1.4	0.99	1.7	0.98	1.8
Ylang-Ylang River	TSS	mg/L	3	99	85	50	50	120	50	180	50	200
Ylang-Ylang River	Fecal Coliform	MPN/100mL	3	210000	55000	180000	180000	230000	180000	270000	180000	280000

Notes: std = Standard Deviation

p25 = 25th percentile of concentrations

p75 = 75th percentile of concentrations

p5 = 5th percentile of concentrations

p95 = 95th percentile of concentrations

MPN = Most Probable Number

Organic Pollution

BOD and DO serve as key indicators of organic pollution. BOD levels above 5 mg/L indicate elevated organic matter loadings, often from sewage or agricultural runoff. Conversely, DO levels below 6 mg/L may reflect oxygen depletion and stress on aquatic life. In this dataset, Manila Bay and Lingayen Gulf exhibit signs of organic enrichment and occasional hypoxia. The variability underscores the influence of temporal factors such as seasonality and hydrodynamic mixing.

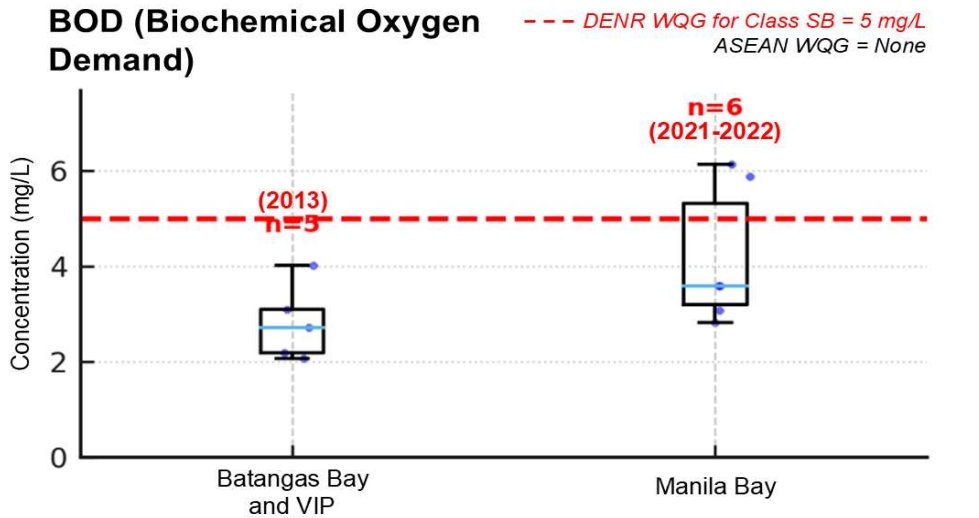


Figure 3.A.1. Box Plot for Biochemical Oxygen Demand in Coastal Pollution Hotspots

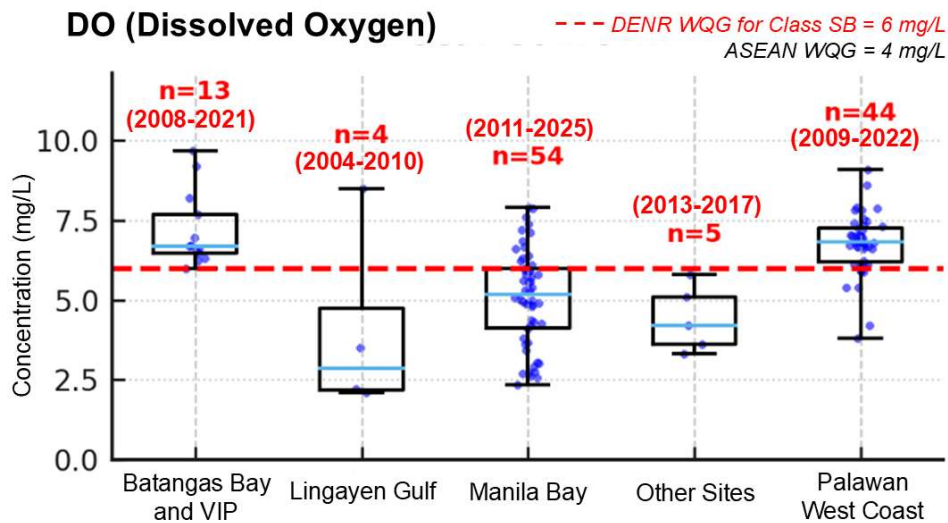


Figure 3.A.2. Box Plot for Dissolved Oxygen in Coastal Pollution Hotspots

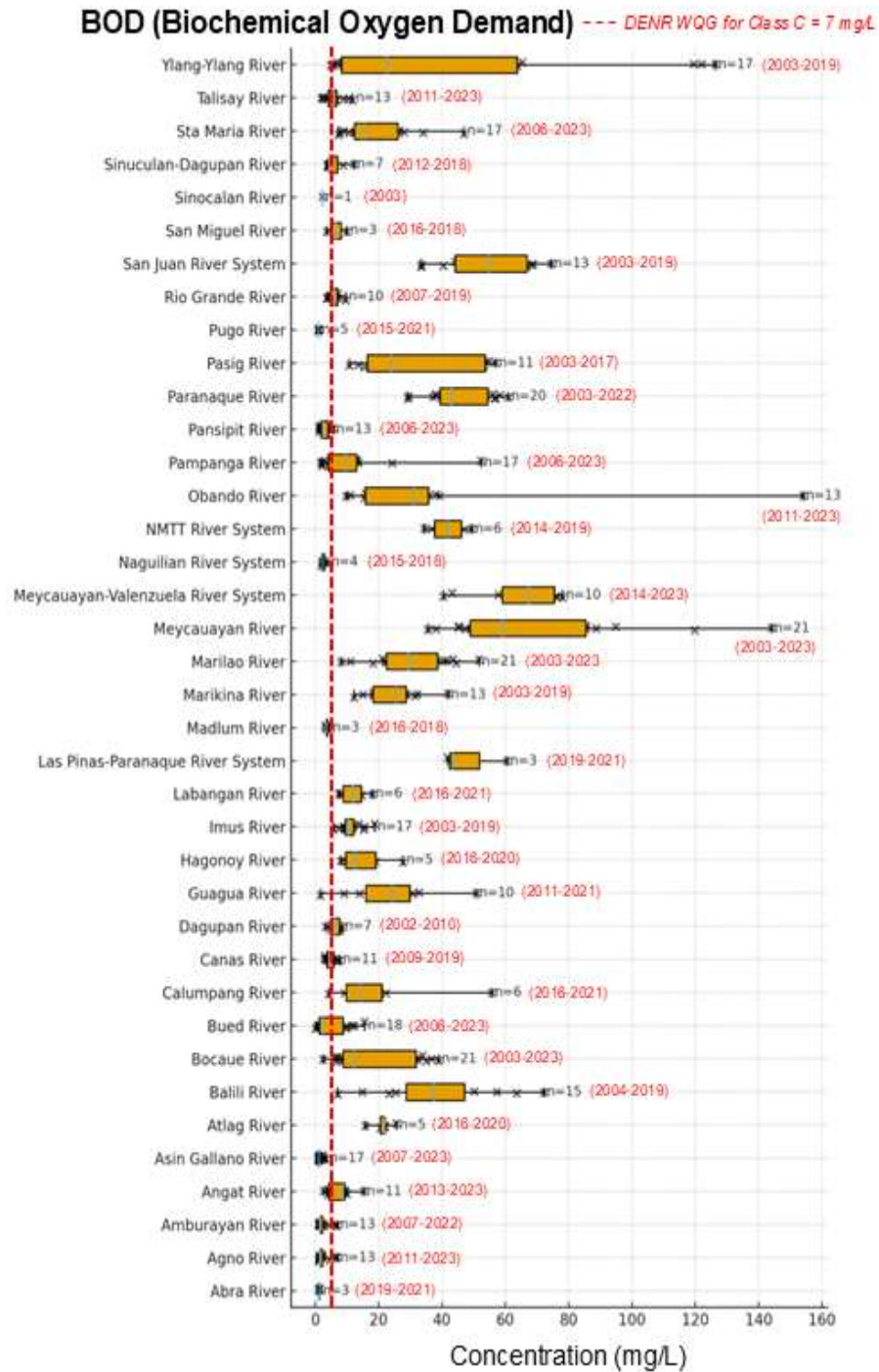


Figure 3.A.3. Box Plot for Biochemical Oxygen Demand in Rivers Draining to Philippine Waters of SCS-LME

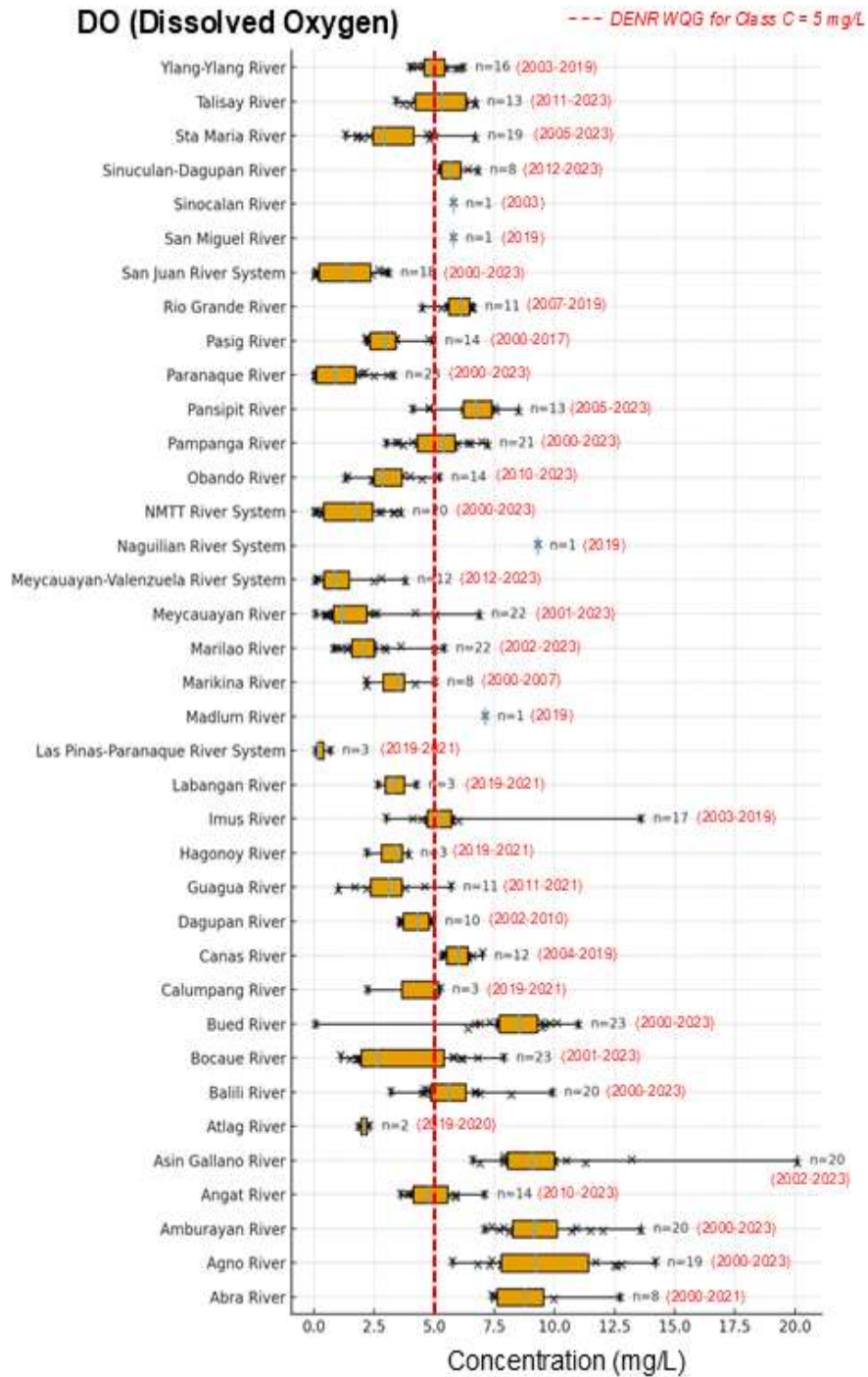


Figure 3.A.4. Box Plot for Dissolved Oxygen in Rivers Draining to Philippine Waters of SCS-LME

Microbial Contaminants

Total and fecal coliform levels provide important indications of microbial contamination linked to untreated domestic wastewater and poor sanitation infrastructure. Exceedances above the thresholds of 1,000 MPN/100 mL (Total Coliform) and 100 MPN/100 mL (Fecal Coliform) suggest elevated public health risks. Sites such as Manila

Bay consistently show high microbial counts. However, caution is advised when interpreting sites with limited samples (small n), as a few extreme values may disproportionately influence medians.

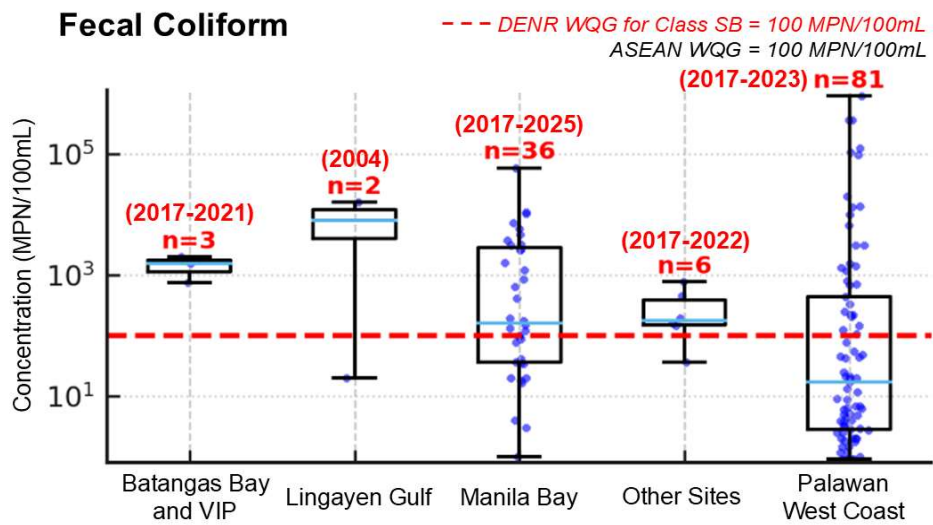


Figure 3.A.5. Box Plot for Fecal Coliform in Coastal Pollution Hotspots

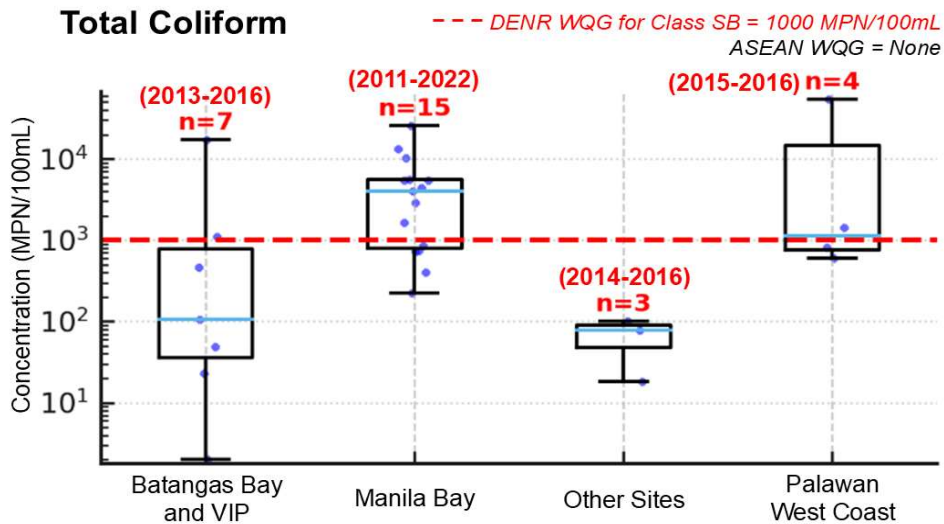


Figure 3.A.6. Box Plot for Total Coliform in Coastal Pollution Hotspots

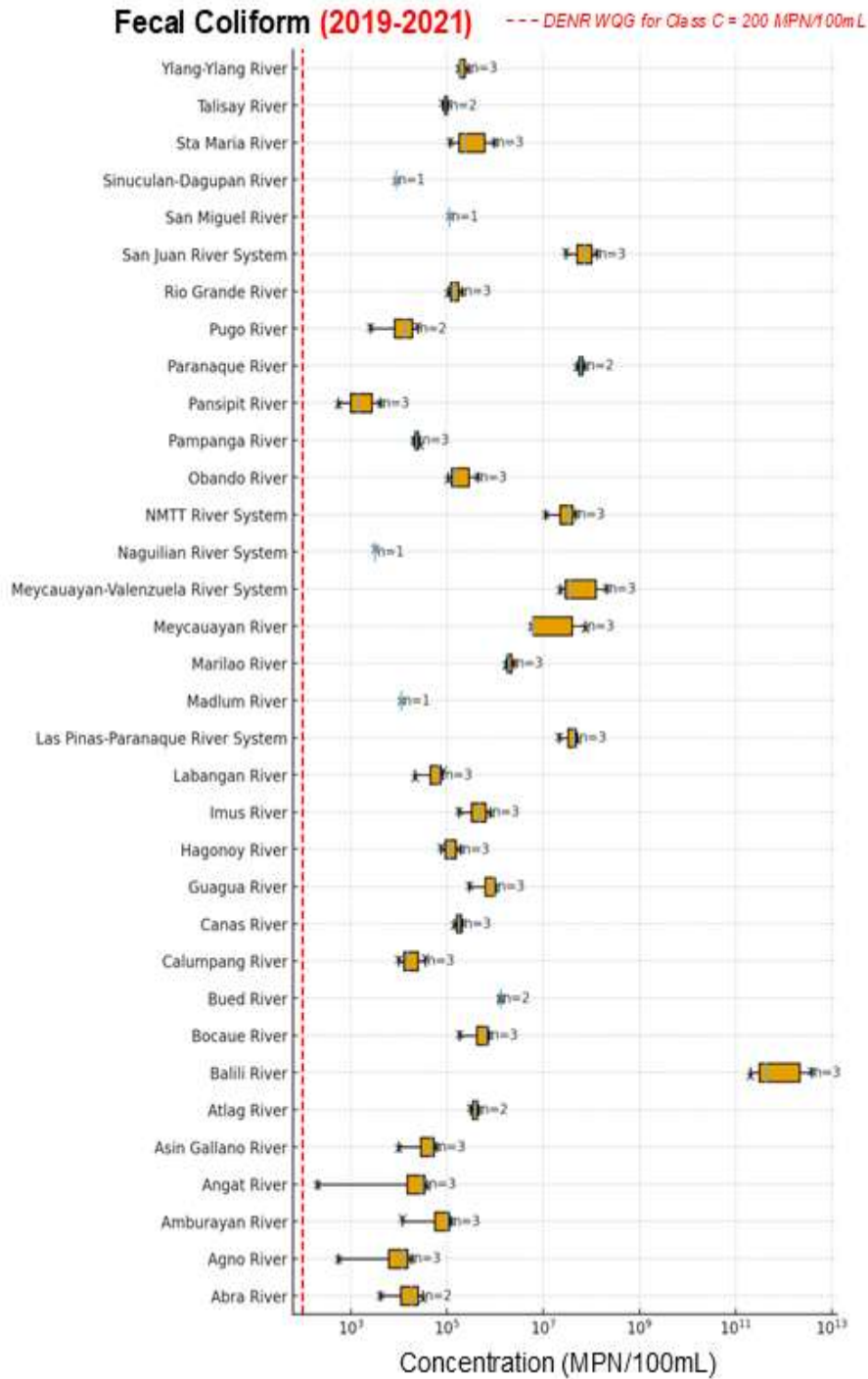


Figure 3.A.7. Box Plot for Fecal Coliform in Rivers Draining to Philippine Waters of SCS-LME

Heavy Metals

Lead and mercury represent toxic trace contaminants with serious ecological and human health implications. Lead values near or above the 0.01 mg/L threshold and mercury near or above 0.001 mg/L highlight risks of industrial and mining discharges, particularly in Manila Bay. While data for mercury are sparse, observed values warrant continued monitoring and stricter pollution control measures.

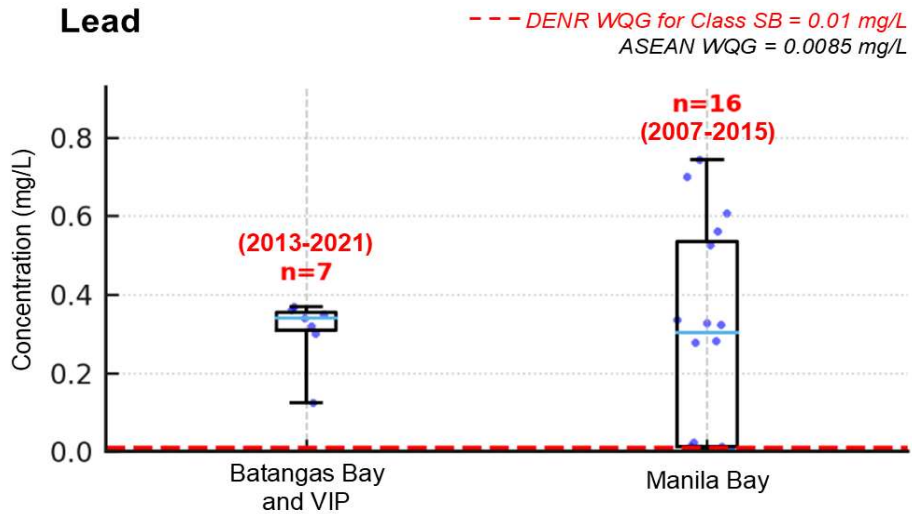


Figure 3.A.8. Box Plot for Lead in Coastal Pollution Hotspots

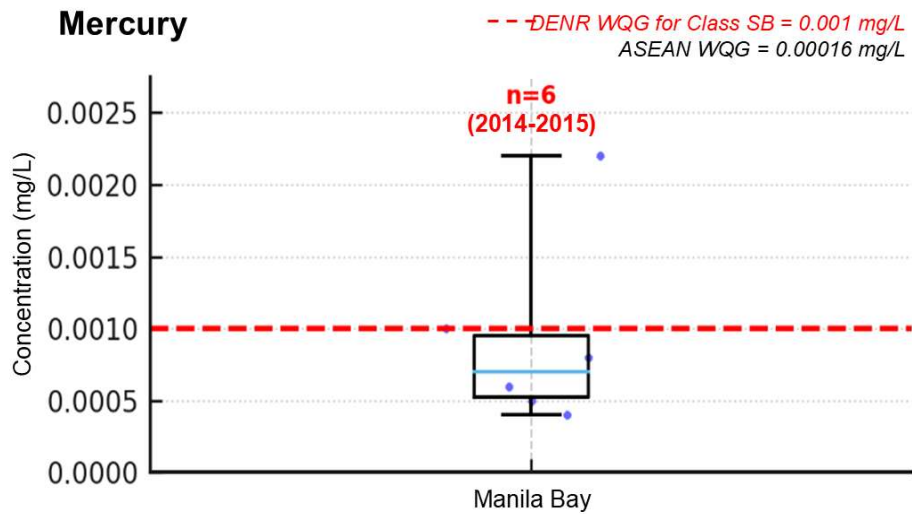


Figure 3.A.9. Box Plot for Mercury in Coastal Pollution Hotspots

Nutrients

Phosphates and nitrates are critical drivers of eutrophication. Concentrations above 0.2 mg/L (phosphates) and 0.06 mg/L (nitrates) suggest risks of algal blooms and water quality degradation. Elevated values are evident in Manila Bay and Palawan West Coast, consistent with inputs from domestic wastewater and agriculture. Care must be taken in interpreting sites with limited data, as nutrient fluxes are highly dynamic and sensitive to rainfall and seasonal agricultural cycles.

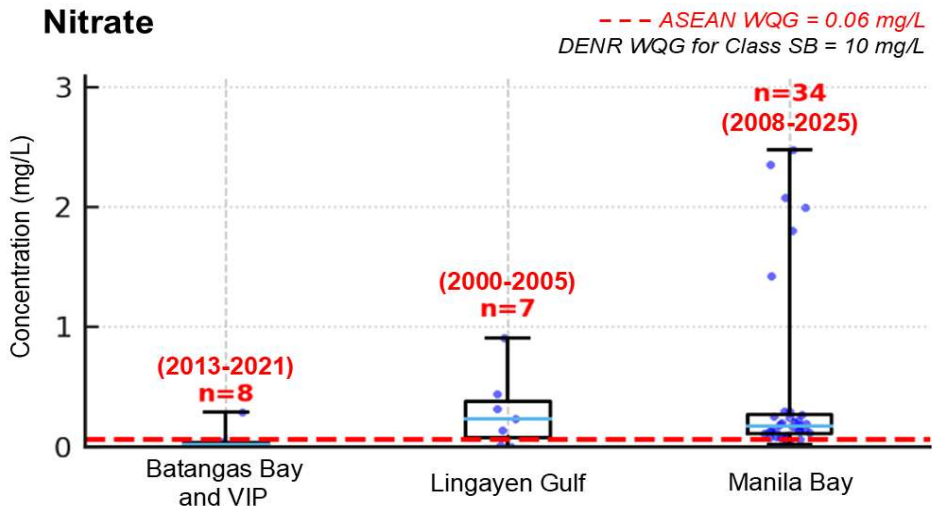


Figure 3.A.10. Box Plot for Nitrate in Coastal Pollution Hotspots

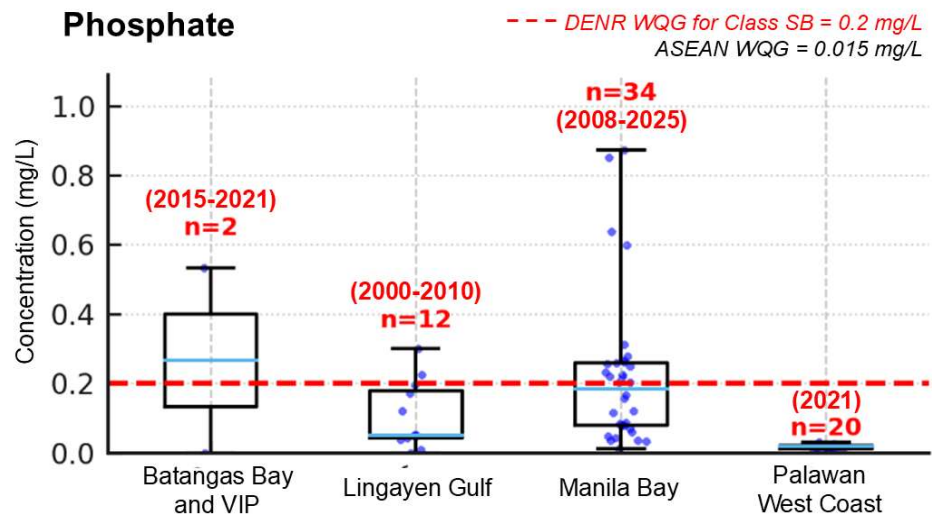


Figure 3.A.11. Box Plot for Phosphate in Coastal Pollution Hotspots

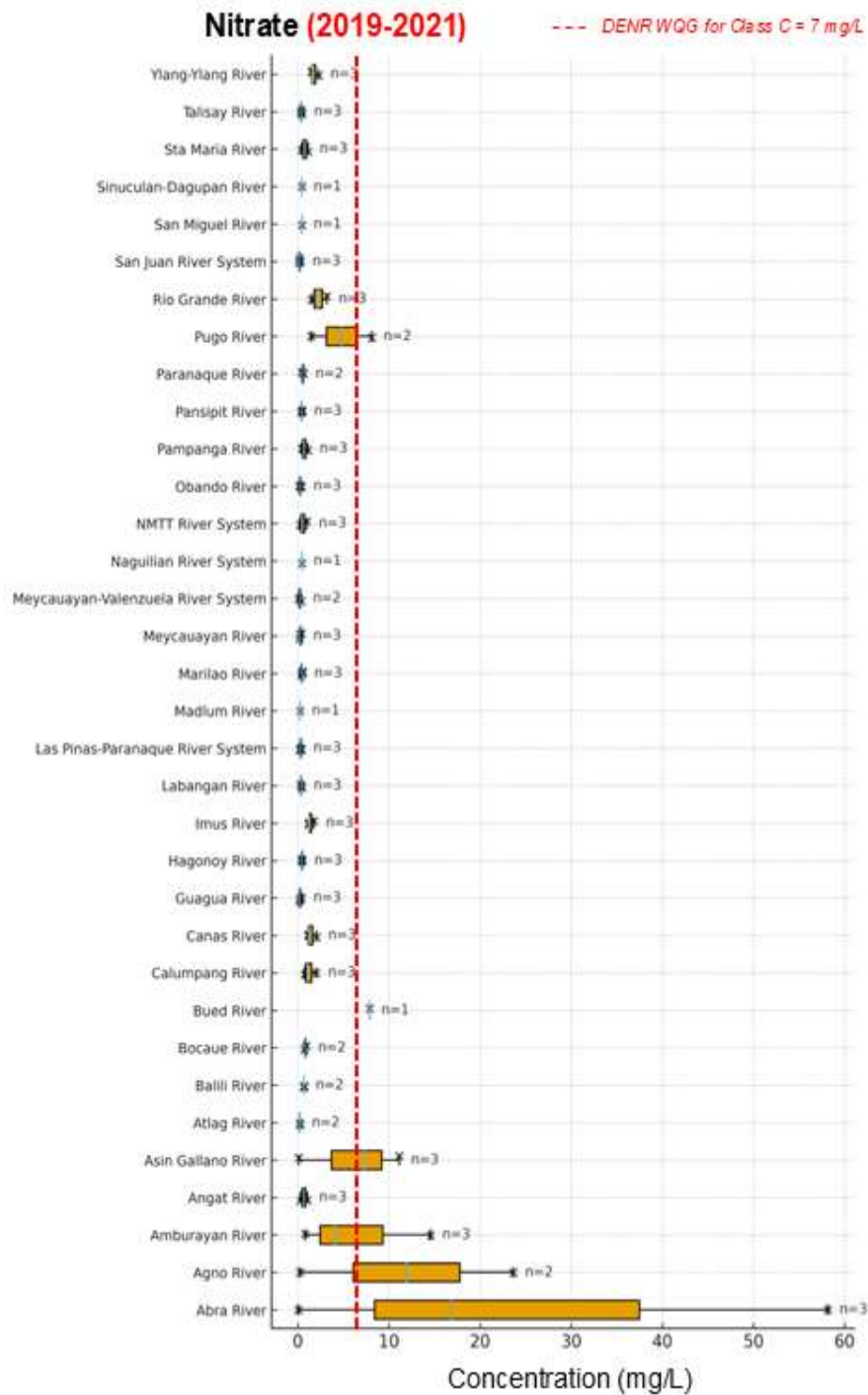


Figure 3.A.12. Box Plot for Nitrate in Rivers Draining to Philippine Waters of SCS-LME

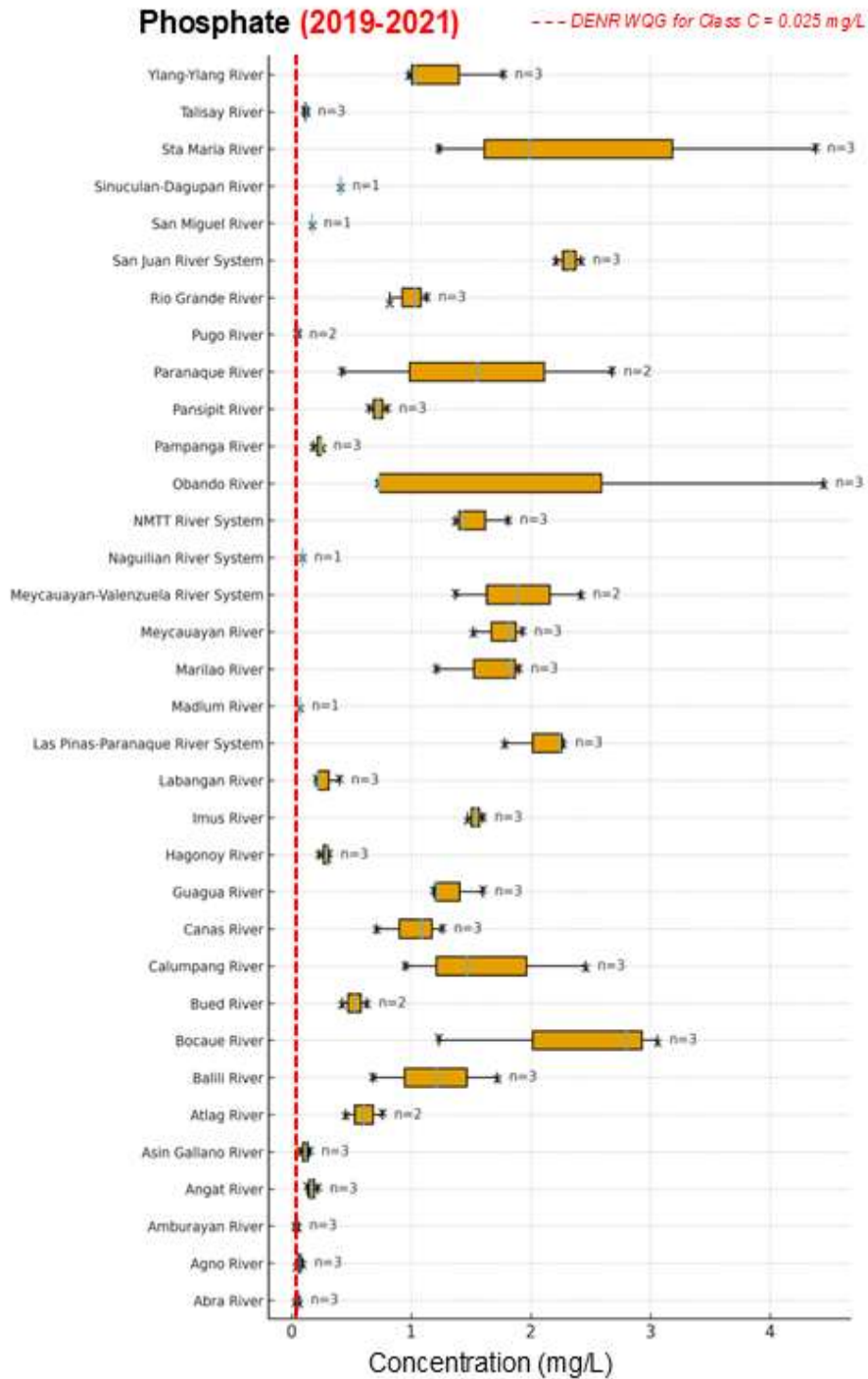


Figure 3.A.13. Box Plot for Phosphate in Rivers Draining to Philippine Waters of SCS-LME

Particles

TSS and microplastics capture different dimensions of particulate pollution. TSS above 80 mg/L indicates high sediment and particulate loads, often driven by erosion, runoff, or reclamation activities. Microplastics are an emerging contaminant of concern, with a provisional threshold of 300 particles/m³ applied here. Sites exceeding this

level highlight risks to aquatic organisms via ingestion and bioaccumulation. The field remains data-limited, and more systematic monitoring is needed.

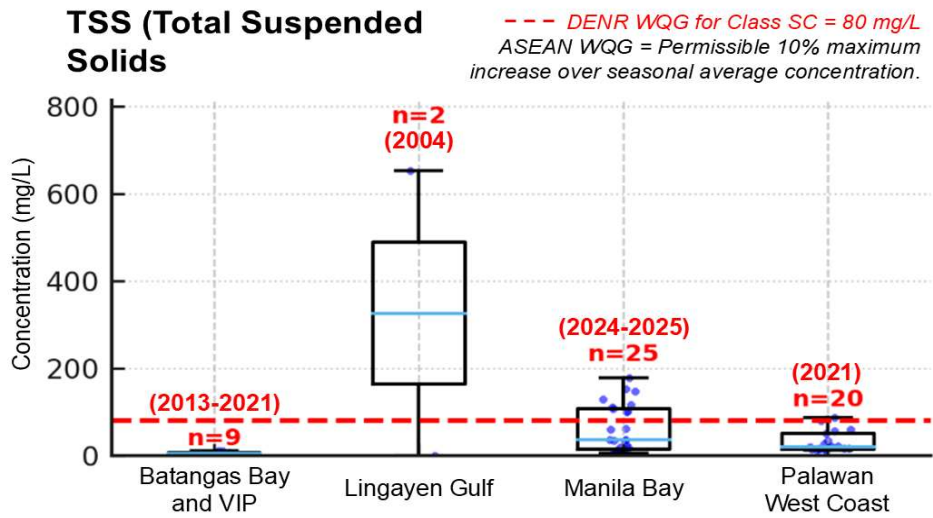


Figure 3.A.14. Box Plot for Total Suspended Solids in Coastal Pollution Hotspots

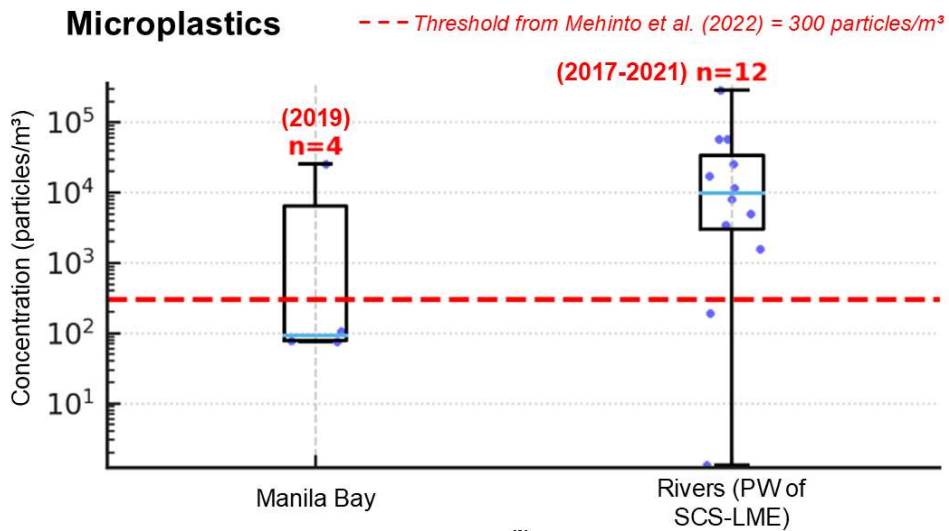


Figure 3.A.15. Box Plot for Microplastics in Coastal Pollution Hotspots

TSS (2019-2021)

--- DENR WQG for Class C = 80 mg/L

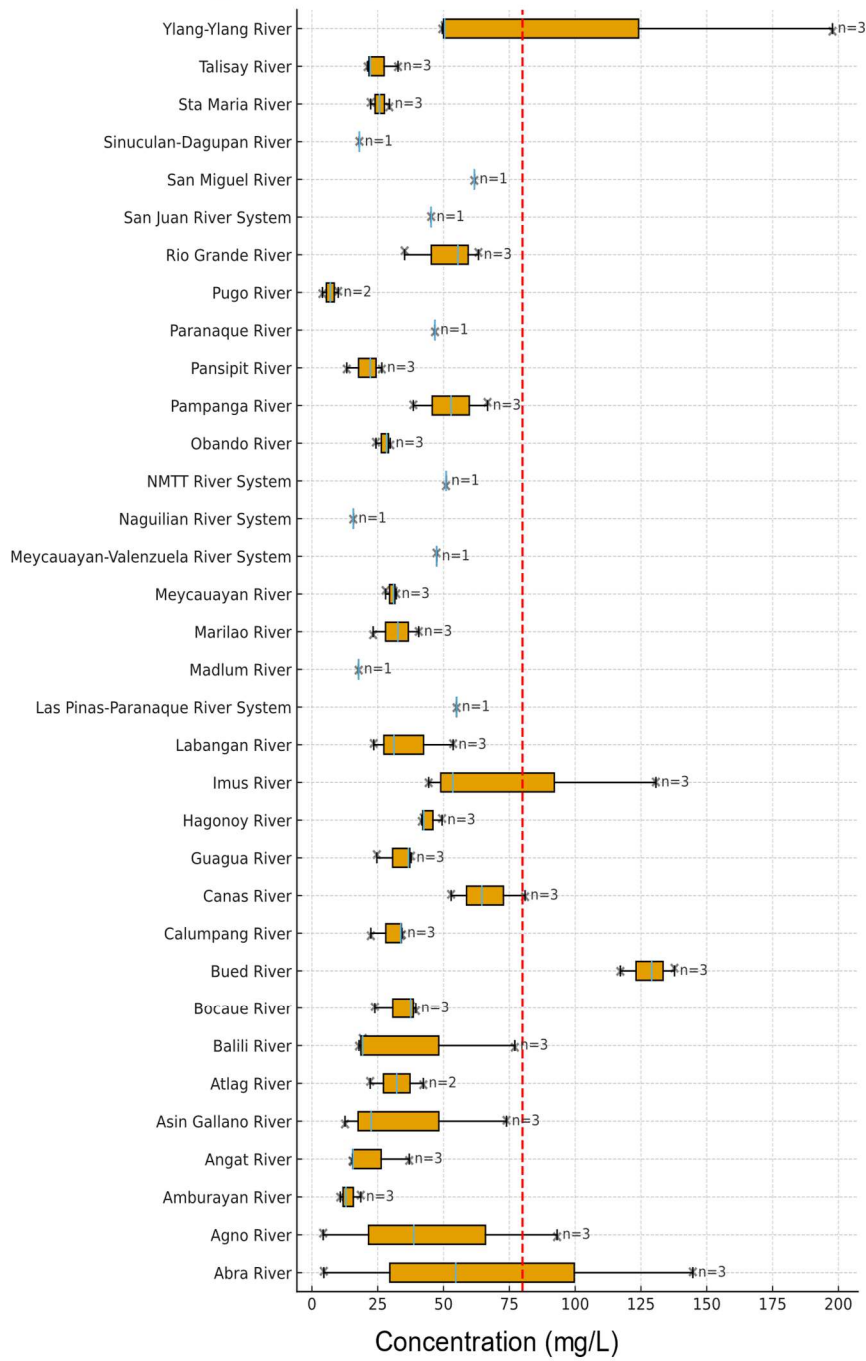


Figure 3.A.16. Box Plot for Total Suspended Solids in Rivers Draining to Philippine Waters of SCS-LME

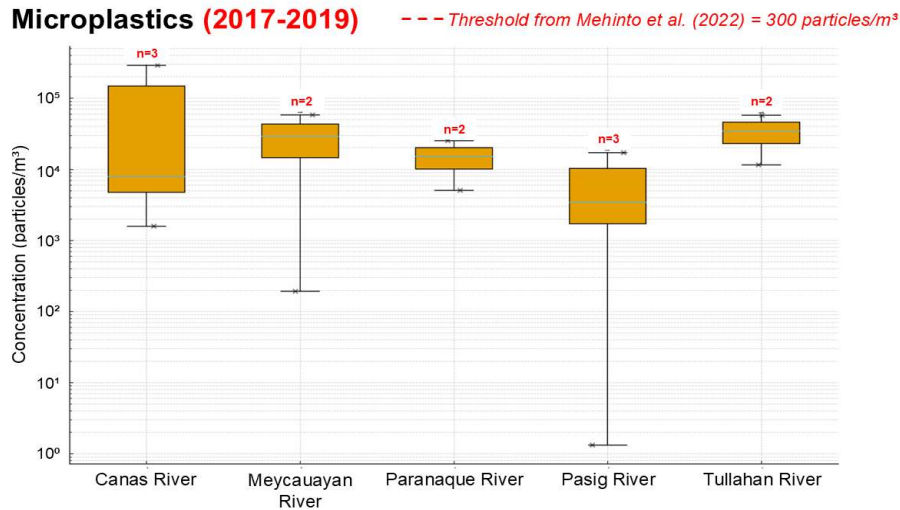


Figure 3.A.17. Box Plot for Microplastic Concentration in Rivers Draining to Philippine Waters of SCS-LME

TARGET SITES

The Philippines has designated the following target sites for implementation of the current Strategic Action Programme for the South China Sea and Gulf of Thailand (SCS SAP): Malampaya Sound Protected Landscape and Seascape (MSPLS) under the municipalities of Taytay and San Vicente in Palawan; Coron and Busuanga in Palawan; and Mabini and Tingloy in Batangas. This section examines the state of these sites in terms of the pollution indicators as well as current interventions done in the municipalities.

Wastewater

Taytay, Palawan (MSPLS)

According to the Palawan Council for Sustainable Development or PCSD (2020), there is no organized sewage disposal in the municipality. Domestic wastewater is discharged to septic tanks and open pits, with some discharged to earth canals that drain to creeks or rivers or simply allowed to seep naturally into the ground.

San Vicente, Palawan (MSPLS)

There is no centralized sewerage system established nor wastewater treatment plant installed in the municipality. However, under the Comprehensive Development Plan for San Vicente, the LGU aims to improve sewerage system in households and public market. Establishment of wastewater treatment facility in Poblacion Public Market and Barangay Port Barton were also included. The LGU also plan to have a strict implementation on discharge permit requirements and conduct information education campaign with the community on the importance of wastewater management (Municipal Planning and Development Office, 2022).

Coron, Palawan

Similarly, there is no sewerage system in Coron (Abrenica et al., 2020). But plans on building a new septage treatment are in talks (Adonis, 2023) and a resolution was released to award the construction of a sewage treatment facility in Coron recently (TIEZA, 2025) all to manage the wastewater issues in the municipality.

Mabini and Tingloy, Batangas

The following issue to be discussed pertains to the entire province of Batangas. In terms of wastewater management, there is limited access to sewage and septage treatment. There is a lack of centralized wastewater connection system and inadequate sanitation and sewerage management. Point sources of untreated wastewater entering the waterways are largely from agricultural (45%) followed by domestic (31%) and industrial (24%). In 2016, around 12.68% of households have no sanitary toilet and resort to open defecation. The province of Batangas, as part of their action program, aims to establish an individual and centralized wastewater treatment facility/sewage treatment plant as per their Strategic Environmental Management Plan (Awitan, 2023).

Solid Waste

Taytay, Palawan (MSPLS)

Overall, poor solid waste management is an issue in the municipality of Taytay. Disposing of garbage through burning were done by 39% of the households in Taytay, 29% through dumping in open pits, 25% by burying, while only 8% are collected by garbage truck and 7% are disposed through garbage pit or composting. Only one garbage truck is in operation which collects waste daily and disposed in an open pit dumpsite in Barangay Poblacion. There is no Material Recovery Facility (MRF) or Sanitary Landfill in the municipality. The increasing solid and liquid waste together with poor waste management leads to environmental and marine pollution in the MSLPS.

Local initiatives include identifying suitable landfill sites and conducting information, education, and communication (IEC) campaigns in schools on proper waste disposal practices. A resolution prohibiting plastic and styrofoam use is currently under consideration, and regular coastal cleanup activities are being implemented. In 2018, the Palawan Council for Sustainable Development (PCSD) approved Taytay's Ten-Year Solid Waste Management Plan (2017-2027) (PCSD, 2020; *MSPLS Protected Area Management Plan 2025-2035*, 2024).

San Vicente, Palawan (MSPLS)

Majority of the waste generated comes from the residential sector at 90.35% based on the Waste Analysis and Characterization Study (WACS) done in 2018 (Table 3.E.4). In terms of waste composition (Table 3.E.5), biodegradable materials constitute the largest proportion at 43.31%, followed by recyclables at 23.86%. The high biodegradable percentage most likely indicates organic waste from food and vegetation. From the conducted WACS, a daily per capita rate of 0.448 kg was computed.

Table 3.A.6. Waste Disposed by Sector in San Vicente, Palawan (2018) (Municipal Planning and Development Office, 2025)

Sector	Kg/day	Kg/yr	Tons/yr	Percentage (%)
Residential	12,715.39	4,641,117.75	4,641.12	90.35
Commercial	1,036.76	378,418.10	378.42	7.37
Institution	296.38	108,177.20	108.18	2.11
Industry	25.57	9,334.27	9.33	0.18
Total	14,074.10	5,127,713.06	5,127.71	100

Table 3.A.7. Waste Disposed by Composition in San Vicente, Palawan (2018) (MPDO, 2025)

Sector	Kg/day	Kg/yr	Tons/yr	Percentage (%)
Biodegradables	6,095.72	2,224,938.37	2,224.94	43.31
Recyclables	3,357.57	1,225,511.66	1,225.51	23.86
Residuals (with potential for diversion)	1,886.47	688,559.83	688.56	13.40
Residuals	2,219.94	810,277.08	810.28	15.77
Special Wastes	514.41	187,760.38	187.76	3.66
Total	14,074.10	5,137,047.32	5,137.05	100

In 2022, waste management practices varied considerably: 62.66% of households segregated waste, 31.55% utilized garbage truck collection services, and 23.97% engaged in composting. However, a large number of households (56.46%) still burned their waste. By 2024, waste infrastructure had improved, with 8 out of 10 barangays having an established MRFs and the LGU is actively pursuing the development of a sanitary landfill. The Solid Waste Management Code of the Municipality of San Vicente, Palawan (Ordinance No. 2006-04-108) is also in place (Municipal Planning and Development Office, 2022; 2025).

Busuanga, Palawan

As of 2020, there is no Sanitary Landfill in the municipality. Most of the garbage waste are disposed by burning or dumping in open pits (Bautista et al. 2020).

Coron, Palawan

In terms of solid waste management in Coron, most of the domestic waste are disposed through open pit in their backyards to naturally decompose, while others throw their wastes unattended in public spaces and coastal area. Only selected barangays are served by dump trucks where a municipal open dump site becomes the final disposal site. There is no established MRF in the municipality.

To mitigate the issue on solid waste, the LGU performs IEC programs on waste management, coastal cleanup activities, and regular garbage collection. A proposal on the establishment of Sanitary Landfill is also underway (Abrenica et al., 2020).

Mabini and Tingloy, Batangas

Waste generation is among the pressing issues in Batangas wherein 874,810 kg/day was generated for 2014-2015. The computed per capita generation is 0.33 kg/day. Biodegradable waste has the highest composition at 47.62%, followed by recyclables (27.37%), residuals (12.15%) while 11.09% of generated waste has potential for diversion. In 2015, the computed per capita generation for Mabini is 0.1149 kg/day while 0.1422 kg/day for the municipality of Tingloy.

The Provincial Government Environment and Natural Resources Office (PGENRO) of Batangas aims for a more effective implementation of RA 9003 (Ecological Solid Waste Management Act) by approved Solid Waste Management Plan (SWMP) for all LGUs with annual reports on the status and implementation. As of 2023, The Ten-Year SWMP of Mabini was approved in 2018 while the Ten-Year SWMP of Tingloy is subject for evaluation. Mabini also has a designated MRF and Sanitary Landfill for waste disposal. The (PGENRO) action program also prioritizes eliminating uncontrolled dumping and open burning while expanding sanitary landfill capacity. The program also encourages community participation through public awareness campaigns on waste management, capacity-building seminars, and training initiatives to enhance knowledge and practices for sustainable agricultural waste management. Small and medium enterprises (SME) are also encouraged to establish recycling facilities and organic farming.

Hazardous Waste

San Vicente, Palawan (MSPLS)

In handling hazardous waste management, the LGU of San Vicente plans to construct a concrete vault as a storage for hazardous waste, provide plastic drums to store collected used oil, and establish storage area for batteries and electronic devices. Operational improvements involve coordinating with Treatment, Storage, and Disposal (TSD) companies and incorporating hazardous waste management provisions into business permit application requirements (Municipal Planning and Development Office, 2022).

Oil Pollution

Malampaya Sound

Given that MSPLS habitat consists primarily of shallow reef flats and steep drop-offs, oil spill incidents could result in severe ecological damage. Oil spills in the area may result from vessel groundings, leakages, collisions, and allisions. Response strategies should prioritize environmentally safe dispersants, solidifiers, and treatment agents while considering potential secondary impacts.

To mitigate the possible threat caused by oil spill, strict compliance to maritime regulations and continuous updated training for personnel are being implemented. Regular monitoring of weather conditions are also done to prevent maritime accidents (Response Plan of MSPLS, Taytay, Palawan 2023-2028, 2025).

Atmospheric Deposition

San Vicente, Palawan (MSPLS)

Air quality management initiatives encompass both monitoring and mitigation strategies. These include the installation of monitoring stations and establishment of airsheds to assess atmospheric conditions, alongside greenhouse gas (GHG) reduction programs such as the Zero Carbon Resort Initiative. Policy frameworks incorporate the Climate Change Program, Clean Development Mechanism, and other carbon crediting initiatives, complemented by enforcement measures such as anti-smoke belching campaigns to reduce vehicular emissions (Municipal Planning and Development Office, 2022).

Annex 3.B. Wastewater Pollution Indicators and Modeled Pollution Load

The dataset was extracted from various government reports by the PSA, NEDA, EMB, and EMB-MBO. This Annex provides the data used for the analysis and visualization, and the formulas to compute the pollution load estimates and removal in wastewater prior to discharge.

Table 3.B.1. Data on wastewater generation and treatment in Metro Manila (2014-2023) (PSA, 2024)

Year	Total wastewater generated (Mm ³ /yr)	Total wastewater treated (Mm ³ /yr)	Total number of facilities	Percentage treated	Average treatment capacity (Mm ³ /facility)
2014	729.69	73.42	56	10%	1.3
2015	754.3	83.67	59	11%	1.4
2016	781.97	95.2	60	12%	1.6
2017	800.04	100.22	60	13%	1.7
2018	824.35	108.72	62	13%	1.8
2019	823.42	119.41	63	15%	1.9
2020	834.21	128.3	63	15%	2.0
2021	806.52	121.76	49	15%	2.5
2022	822.21	120.32	49	15%	2.5
2023	843.75	121.66	49	14%	2.5

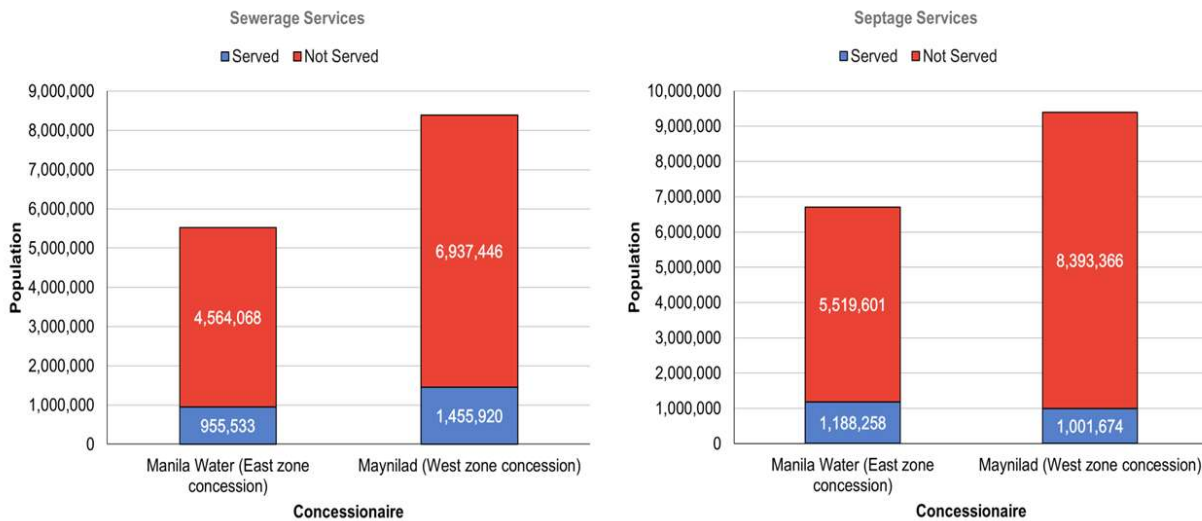


Figure 3.B.1 Sewerage and Septage Services in Metro Manila as of 2017. Stacked-bar chart showing the population in the East and West Zone of Metro Manila with and without sewerage services (left panel) and septage services (right panel) (NEDA, 2021).

Table 3.B.2. Septage and Sewerage Coverage of MWSS Concessionaires in Metro Manila, 2017, Data source: NEDA, 2021

Concessionaire	Total Population	Septage Population Served	Population Not Served with Septage	Septage Coverage (%)	Not Served (%)	Sewerage Population Served	Population Not Served with Sewerage	Sewerage Coverage (%)	Not Served (%)
Manila Water (East zone concession)	5,519,601	1,188,258	4,331,343	21.5%	78.5%	955,533	4,564,068	17.1%	82.9%
Maynilad (West zone concession)	8,393,366	1,001,674	7,391,692	12.0%	88.0%	1,455,920	6,937,446	17.3%	82.7%

Manila Water (East zone concession)	6,707,859	1,188,258	5,519,601	17.7	82.29	955,533	4,564,068	14.2	68.04
Maynilad (West zone concession)	9,395,040	1,001,674	8,393,366	10.7	89.34	1,455,920	6,937,446	15.5	73.84
Total	16,102,899	2,189,932	13,912,967	13.6	86.40	2,411,453	11,501,514	15	71.43

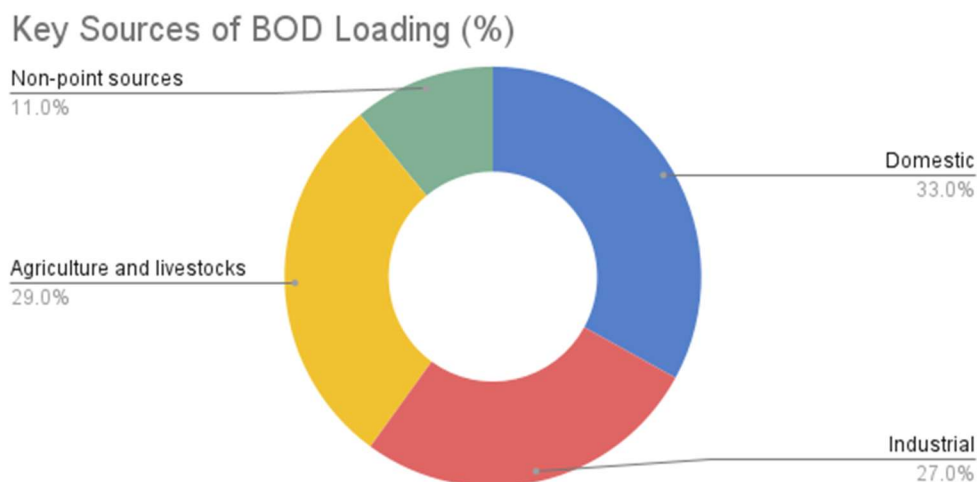


Figure 3.B.2. Four Key Sources of BOD Loading for Water Pollution. Data source: EMB DENR (2020b).

Pollution Load Estimates from Domestic Wastewater

Nomenclature

HDWL – Household Waste Load, (kg/day, for Fecal Coliform – MPN/day)

SF – Sewage Flow (use 50 gal/cap/day based in PD 856)

PUL – Pollution Unit Load assumption

HDPL – Household Pollution Load (kg/day, for Fecal Coliform – MPN/day)

TE – Treatment Efficiency

PLR – Pollution Load Removed

To estimate the domestic pollution load, the EMB Memorandum Circular 2020-25 (EMB, 2020a) was used as a reference. The calculation applied the Philippine Statistics Authority’s 2025 projected mid-year population, aggregating the populations of provinces expected to contribute wastewater from the watershed or river basins into the Philippine waters of the SCS-LME. Provinces included specifically are NCR, Benguet, Abra, Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Batanes, Zambales, Nueva Ecija, Tarlac, Bataan, Pampanga, Bulacan, Cavite, Batangas, Laguna, Rizal, Occidental Mindoro, Palawan, and some municipalities/cities in Mountain Province, Nueva Vizcaya, Aurora, Quezon, and Oriental Mindoro. The following formula was used to calculate the domestic waste generated:

$$\mathbf{HDWL = Population \times SF \times PUL}$$

Table 3.B.3. Household Domestic Pollution Unit Load (PUL) Assumption (Tchobanoglus et al., 2003)

Parameter/Pollutant	Pollution Unit Load or Concentration	Unit
Biochemical Oxygen Demand (BOD5)	200	mg/L
Chemical Oxygen Demand (COD)	508	mg/L
Nitrate as NO3-N	35	mg/L
Phosphate as Phosphorus	5.6	mg/L
Total Suspended Solids	195	mg/L
Fecal Coliform	10,000 – 1,000,000	MPN/100mL

Table 3.B.4. Projected 2025 Mid-Year Population in Selected Provinces (PSA, 2025)

Region	Province	Population	Year
NCR	NCR	14,521,657	2025
CAR	Mountain Province (2 municipalities)	25,306	2025
CAR	Benguet	892,600	2025
CAR	Abra	252,070	2025
Region 1	Ilocos Norte	628,200	2025
Region 1	Ilocos Sur	735,053	2025
Region 1	La Union	859,561	2025
Region 1	Pangasinan	3,235,249	2025
Region 2	Batanes	18,571	2025
Region 2	Nueva Vizcaya (5 municipalities)	115,108	2025
Region 3	Aurora (3 municipalities)	105,318	2025
Region 3	Zambales	949,718	2025
Region 3	Nueva Ecija	2,582,695	2025
Region 3	Tarlac	1,533,124	2025
Region 3	Bataan	896,684	2025
Region 3	Pampanga	3,115,786	2025
Region 3	Bulacan	3,923,826	2025
Region 4A	Cavite	4,639,491	2025
Region 4A	Batangas	3,423,043	2025
Region 4A	Laguna	3,583,594	2025
Region 4A	Quezon (2 municipalities)	75,777	2025
Region 4A	Rizal	3,464,226	2025
Region 4B	Occidental Mindoro	536,768	2025
Region 4B	Oriental Mindoro (4 municipalities/cities)	257,737	2025
Region 4B	Palawan	1,303,583	2025
TOTAL		51,674,745	

To estimate the pollution load removed through onsite sanitation systems, it was assumed that approximately 90% of households have access to sanitation facilities, based on the 2024 CPES report from the PSA. In 2021, the proportion of households with improved sanitation facilities in regions bordering the SCS-LME ranged from 91.9% to 99.3%; thus, a conservative estimate of 90% was applied. In this scenario, this 90% is assumed to be connected to

septic tanks; thus, a 25% treatment efficiency was applied. Additionally, it was assumed that 5% of the population is connected to Wastewater Treatment Facilities (WWTFs) (Tuddao, 2019), while the remaining 5% discharge directly into waterways. All computations are subject to a 5% margin of error. The pollution load removed was then computed using the following formula:

$$\text{HDPL} = [\text{HDWL} \times 90\% \times (1-\text{TE}_{\text{septic}})] \times [\text{HDWL} \times 5\% (1-\text{TE}_{\text{WWTF}})] + [\text{HDWL} \times 5\% \times (1-\text{TE}_{\text{direct}})]$$

$$\text{PLR} = \text{HDWL} - \text{HDPL}$$

Table 3.B.5. Treatment Efficiency (TE) Assumption (EMB, 2020a)

Treatment	Efficiency
WWTF	60% or (1-0.60)
Septic Tank	25% or (1-0.25)
Direct Discharge or raw/untreated	0%

Table 3.B.6. Estimated Pollution Load on Selected Provinces based on PSA’s Projected Population for 2025

Indicator	HDWL	HDPL	PLR
BOD	710,000±36,000	530,000±27,000	180,000±9,100
COD	1,800,000±91,000	1,400,000±68,000	460,000±23,000
Nitrate as NO ₃ -N	120,000±6,200	93,000±4,700	32,000±1,600
Phosphate as Phosphorus	20,000±1,000	15,000±740	5,100±250
TSS	700,000±35,000	520,000±26,000	180,000±8,900

Table 3.B.7. Fecal Coliform statistics in Manila Bay (19 Monitoring Stations) (EMB-MBO, 2016)

Year	Geometric Mean (MPN/100mL)	Min Count (MPN/100mL)	Max Count (MPN/100mL)	% Exceed 200 MPN
2011	5,429	1,150.00	33,000.00	100.0%
2012	10,149	85.08	160,000.00	85.7%
2013	13,389	393.28	540,000.00	100.0%
2014	5,396	266.00	200,000.00	100.0%
2015	25,517	183.33	5,580,000.00	94.1%

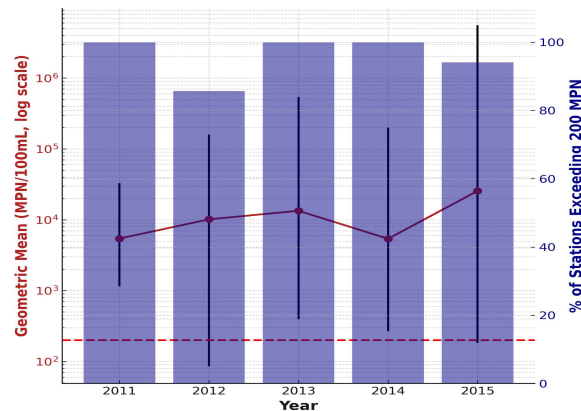


Figure 3.B.3. Fecal Coliform Levels in Manila Bay in 19 Monitoring Stations (2011-2015) (EMB-MBO, 2016).

Table 3.B.8. Pollution Load Data on Wastewater from Selected Regions in the Philippines (2019) (EMB, 2020b).

Region	BOD (tons)	COD (tons)	Nitrate (tons)	Phosphate (tons)	TSS (tons)	Fecal Coliform (MPN/100mL)
NCR	143,231.88	363,808.98	25,065.58	4,010.49	139,651.09	1.99E+14
CAR	20,954.34	53,224.02	3,667.01	586.72	20,430.48	2.91E+13
Region I	57,842.79	146,920.68	10,122.49	1,619.60	56,396.72	8.03E+13
Region II	41,040.63	104,243.19	7,182.11	1,149.14	40,014.61	5.70E+13
Region III	132,959.72	337,717.70	23,267.95	3,722.87	129,635.73	1.85E+14
Region IV-A	171,082.65	434,549.93	29,939.46	4,790.31	166,805.58	2.38E+14
MIMAROPA	36,192.56	91,929.10	6,333.70	1,013.39	35,287.75	5.03E+13

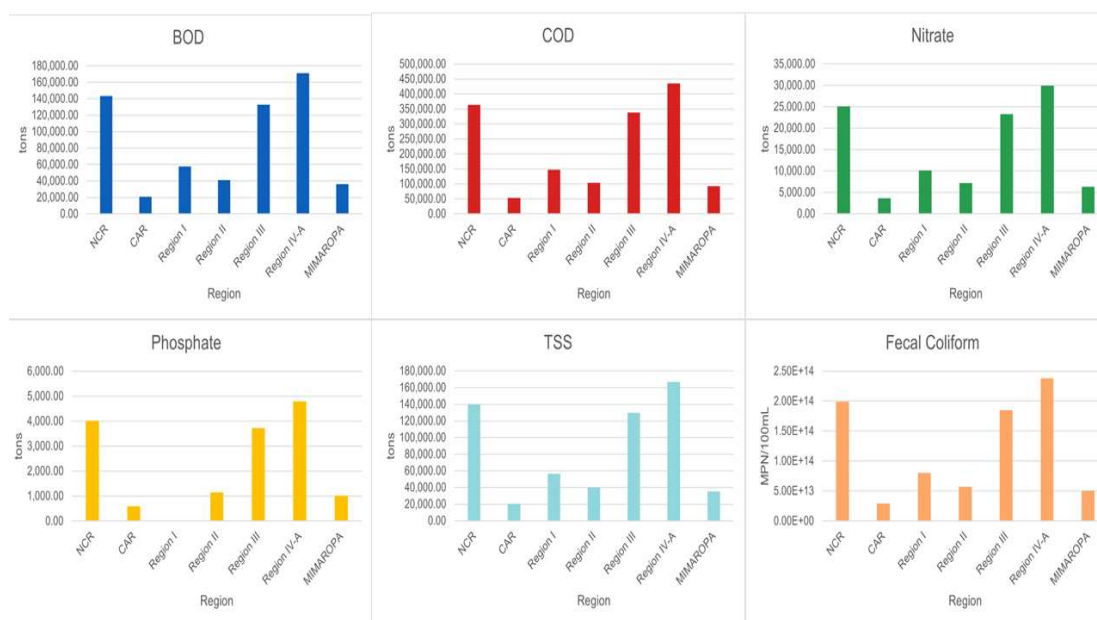


Figure 3.B.4. Projected Pollution Load on Wastewater from Selected Regions in Philippines for 2019 (EMB, 2020b).

Table 3.B.9. Sectoral profile of manufacturing plants

Sector	Typical product streams	Environmental signature/key pollutant
Pulp & paper	Kraft paper, newsprint, packaging board	High-BOD & color in wastewater; fibre sludge
Sugar mills & alcohol distilleries	Raw & refined sugar, bioethanol, rum	Molasses-rich, high-BOD effluent; bagasse waste
Food processing	Canned fruit, meat, beverages	Organic-rich effluent; oil & grease

Plastic & consumer goods	Flexible packaging, toys, housewares	Solvent VOCs; pellet micro-plastics
Base-material plants	Copper smelter, glass and steel works, cement kilns	Metal particulates; SO ₂ /NO _x ; slag
Electronics assembly & aerospace	Semiconductors, PCB, aircraft parts	Acid/alkali rinse water; PFAS; heavy metals
Textiles	Garments, yarn, and fabric dyeing	Dyestuff-laden wastewater; high TDS
Petroleum refining & shipbuilding	Fuels, lubricants, and ocean-going vessels	Hydrocarbon effluent, bilge & sludge oils

Table 3.B.10. Wastewater qualities of selected industry types in the Philippines (WEPA, 2024)

Industry	BOD (mg/L)	COD (mg/L)	TSS (mg/L)	Temp (°C)	pH
Sugarcane milling	2,000–3,500	6,000	800–1,000	–	6.5–8.0
Manufacture of ethanol	60,000	110,000	6,000	48–50	4–4.5
Canning of fish products	30,000	45,000	10,700	25	6.5–7.5
Manufacture of beverages	900	1,500	250	25	11–12
Meat processing	1,000–1,500	2,000	250	–	7
Copper cathode	–	–	43	30.4	8.15
Swine farm	2,000–4,200	4,000–5,429	1,600–5,380	–	–
Bottling services	400	1,647.05	90	32.2	8.35
Manufacturing of desiccated coconut	6,000–10,000	17,000–20,000	2,000–4,000	–	5.0–6.3
Pineapple processing plant	10,200	20,000	585	40–50	4.5–6.5

Annex 3.C. Agricultural Runoff and Diffuse Pollution Indicators

The dataset on pesticide and fertilizer use in the Philippines was extracted from the Food and Agriculture Organization’s (2025) database to create time-series graphs illustrating trends in agricultural inputs over time. Data on nutrient loads in selected watersheds and river basins were sourced from Magcale-Macandog et al. (2016). A summary table of all data and figures is provided in the annex.

Table 3.C.1. Fertilizer Use per Area from 2000-2022 (FAO, 2025a; FAO, 2025b)

Spatial Coverage	Year	Unit	N Fertilizer	P Fertilizer	K Fertilizer	Pesticide
Philippines	2000	kg/ha	50.2	12.8	12.6	1.8
Philippines	2001	kg/ha	52.4	15.4	13	1.8
Philippines	2002	kg/ha	46.2	13.4	11.7	1.9
Philippines	2003	kg/ha	58.8	13.3	13.1	1.9
Philippines	2004	kg/ha	63.2	13	12.1	1.8
Philippines	2005	kg/ha	55.2	13.9	10.4	1.9
Philippines	2006	kg/ha	47.1	14.8	11.6	1.9
Philippines	2007	kg/ha	50.5	19.9	11.4	1.9
Philippines	2008	kg/ha	38.2	7.5	8.7	1.9
Philippines	2009	kg/ha	40.4	6.2	16.5	1.9
Philippines	2010	kg/ha	56	8.7	11	2
Philippines	2011	kg/ha	48.2	14	11.2	2
Philippines	2012	kg/ha	43	7.4	10.1	2
Philippines	2013	kg/ha	48.1	18.4	13	2
Philippines	2014	kg/ha	54.2	12.4	13.5	2
Philippines	2015	kg/ha	47.8	11.9	11	2.1
Philippines	2016	kg/ha	56.8	14.3	14.7	2
Philippines	2017	kg/ha	68.7	18.8	19.7	1.9
Philippines	2018	kg/ha	58.5	12	14.6	1.9
Philippines	2019	kg/ha	63.7	15.9	18.6	2.2
Philippines	2020	kg/ha	67.3	18.5	19.1	3.1
Philippines	2021	kg/ha	64	23.1	28.9	3.4
Philippines	2022	kg/ha	71.5	35.9	35.3	3.4

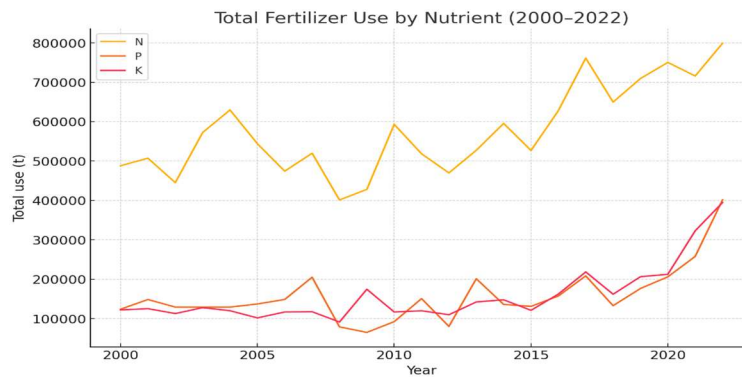


Figure 3.C.1. Trend of Annual Total Fertilizer Use (2000-2022)

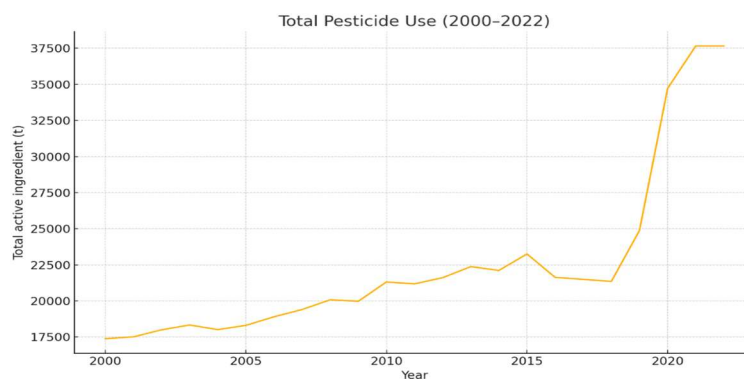


Figure 3.C.2. Trend of Annual Total Pesticide Use (2000-2022)

Table 3.C.2. Fertilizer Use by Mass Input per Year from 2000-2022 (FAO, 2025a; FAO, 2025b)

Spatial Coverage	Year	Unit	N Fertilizer	P Fertilizer	K Fertilizer	Pesticide
Philippines	2000	tons/yr	488,177	124,113	122,260	17382.7
Philippines	2001	tons/yr	507,348	148,655	125,412	17509.8
Philippines	2002	tons/yr	445,244	129,401	113,000	17995.3
Philippines	2003	tons/yr	572,571	129,401	128,000	18330.6
Philippines	2004	tons/yr	629,808	129,401	120,200	18010.9
Philippines	2005	tons/yr	544,134	137,311	102,000	18304
Philippines	2006	tons/yr	474,332	148,819	117,000	18899
Philippines	2007	tons/yr	519,960	205,168	117,612	19403.5
Philippines	2008	tons/yr	401,297	79,239	91,567	20075.7
Philippines	2009	tons/yr	428,140	65,149	174,660	19975.8
Philippines	2010	tons/yr	593,226	92,446	116,936	21311.1
Philippines	2011	tons/yr	518,448	150,962	120,084	21179.5
Philippines	2012	tons/yr	470,000	80,400	110,000	21608
Philippines	2013	tons/yr	527,459	201,419	142,463	22374.1
Philippines	2014	tons/yr	595,539	136,122	147,889	22111.6
Philippines	2015	tons/yr	526,906	131,228	121,243	23250.7
Philippines	2016	tons/yr	628,136	157,588	162,480	21632.1
Philippines	2017	tons/yr	761,288	208,515	218,624	21491.3
Philippines	2018	tons/yr	649,676	132,990	162,050	21350.5
Philippines	2019	tons/yr	709,569	176,654	206,534	24879
Philippines	2020	tons/yr	750,453	206,193	212,602	34715.3
Philippines	2021	tons/yr	715,904	258,040	323,078	37660.4
Philippines	2022	tons/yr	799,021	401,638	394,868	37660.4

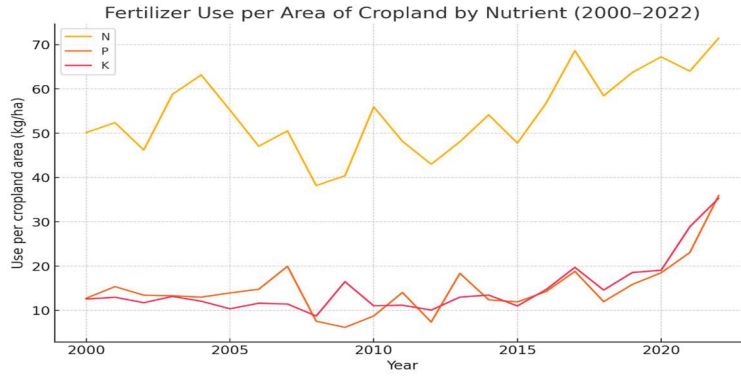


Figure 3.C.3. Trend of Annual Fertilizer Use per Area of Cropland (2000–2022)

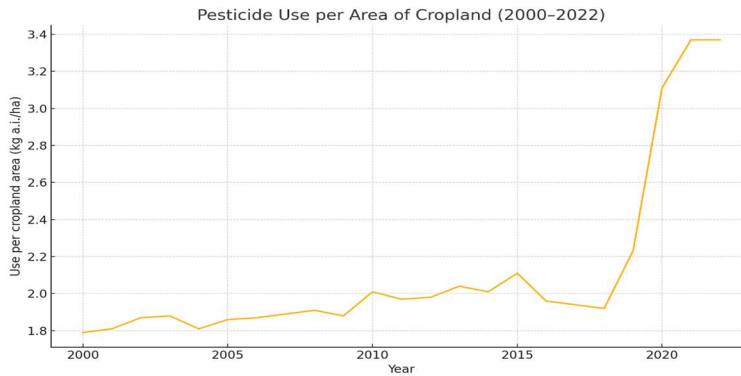


Figure 3.C.4. Trend of Pesticide Use per Area of Cropland (2000–2022)

Table 3.C.3 Nutrient Load in Selected Watersheds and River Basins, kg/day (2016) (Magcale-Macandog et al., 2016).

Watershed	Ammonium	Nitrate	Phosphorus
Pampanga River Basin	482.89	590.2	1,663.29
Pasig River Basin	372.82	3,089.74	861.24
Bataan Watershed	274.58	646.09	1,788.88
Cavite Watershed	114.95	199.97	336.1

Annex 3.D. Aquaculture Pollution Indicators

The Philippines' Bureau of Fisheries and Aquatic Resources (BFAR) is responsible for the development, improvement, law enforcement, management, and conservation of the Philippines' fisheries and aquatic resources. BFAR plays a crucial role in the management of aquaculture in the country. Since HAB events directly impact fisheries and aquaculture, including fish kills and shellfish toxicity, BFAR monitors these events and shares this information to the Intergovernmental Oceanographic Commission. The dataset for the frequency of shellfish advisories to visualize harmful algal bloom occurrences in the Philippines was extracted from the Intergovernmental Oceanographic Commission (2025). Data on fish kills were obtained from academic journals.

Table 3.D.1. Occurrence of Harmful Algal Bloom in the Philippines (2000-2025) (Intergovernmental Oceanographic Commission, 2025)

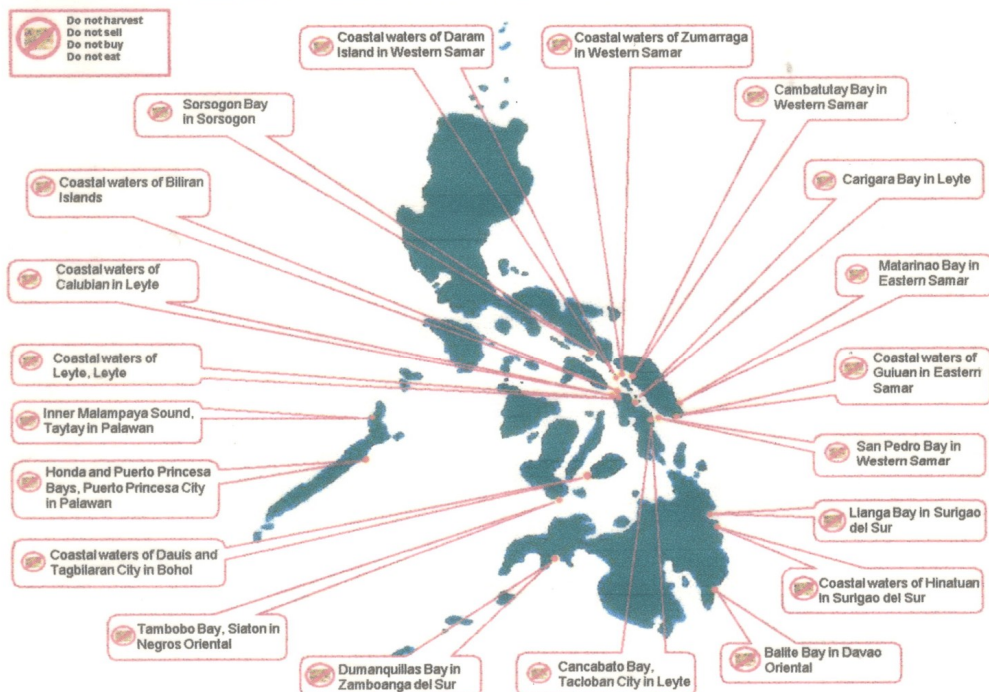
Year	Philippines	Philippine Waters of SCS-LME	% of Occurrence in SCS-LME to National
2000	10	2	20.0%
2001	5	2	40.0%
2002	12	4	33.3%
2003	9	2	22.2%
2004	10	3	30.0%
2005	10	4	40.0%
2006	9	2	22.2%
2007	16	2	12.5%
2008	12	2	16.7%
2009	6	1	16.7%
2010	13	4	30.8%
2011	11	4	36.4%
2012	10	4	40.0%
2013	9	2	22.2%
2014	11	5	45.5%
2015	13	4	30.8%
2016	14	1	7.1%
2017	1	1	100.0%
2018	155	18	11.6%
2019	180	37	20.6%
2020	342	33	9.6%
2021	84	6	7.1%
2022	24	2	8.3%
2023	13	0	0.0%
2024	127	3	2.4%
2025	39	3	7.7%



Republic of the Philippines
 Department of Agriculture
BUREAU OF FISHERIES AND AQUATIC RESOURCES
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Shellfish Bulletin No. 02
Series of 2021
 28 January 2021

Based on the latest laboratory results of the Bureau of Fisheries and Aquatic Resources (BFAR) and Local Government Units (LGUs), shellfishes collected at **Honda and Puerto Princesa Bays in Puerto Princesa City, and Coastal waters of Inner Malampaya Sound, Taytay in Palawan; Sorsogon Bay in Sorsogon; Coastal waters of Dausi and Tagbilaran City in Bohol; Tambobo Bay, Siaton in Negros Oriental; Coastal waters of Dararam Island, Zumarraga, and Cambatutay Bay in Western Samar; Coastal waters of Calubian, Leyte, Carigara Bay, and Cancabato Bay, Tacloban City in Leyte; Coastal waters of Biliran Islands; Coastal waters of Guianan and Matarinao Bay in Eastern Samar; Balite Bay, Mati City in Davao Oriental; Lianga Bay and Coastal waters of Hinatuan in Surigao del Sur; and Dumanquillas Bay in Zamboanga del Sur** are still **positive** for paralytic shellfish poison that is beyond the regulatory limit. **Moreover, San Pedro Bay in Western Samar is now positive for red tide toxin.**



All types of shellfish and *Acetes sp.* or *alamang* gathered from the areas shown above are NOT SAFE for human consumption. Fish, squids, shrimps and crabs are safe for human consumption provided that they are fresh and washed thoroughly, and internal organs such as gills and intestines are removed before cooking.

The following areas continue to be **FREE from toxic red tides**: coastal waters of Cavite, Las Piñas, Parañaque, Navotas, Bulacan and Bataan (Mariveles, Limay, Orion, Pilar, Balanga, Hermosa, Orani, Abucay and Samal) in Manila Bay; coastal waters of Bolinao, Anda, Alaminos, Sual and Wawa, Bani in Pangasinan; coastal waters of Pampanga; Masinloc Bay in Zambales; coastal waters of Mandaon in Masbate; Juag Lagoon, Matnog in Sorsogon; coastal waters of Gigantes Islands, Carles in Iloilo; coastal waters of Pilar, Panay, President Roxas and Roxas City in Capiz; Sapián Bay (Ivisan and Sapián in Capiz; Mambuquiao and Camanci, Batán in Aklan); Altavas, Batán and New Washington in Batán Bay, Aklan; coastal waters of E.B. Magalona, Talisay City, Silay City, Bacolod City, Hinigaran and Victorias City in Negros Occidental; Silt Bay, Siaton and Bals Bay, Bals City in Negros Oriental; Irong-Irong, Maqueda and Villareal Bays in Western Samar; Ormoc Bay, Ormoc City in Leyte; Panguil Bay, Tangub City in Misamis Occidental; Murcielagos Bay in Zamboanga del Norte and Misamis Occidental; Taguines Lagoon, Benoni, Mahinog in Camiguín Island; Coastal waters of Nasipit in Agusan del Norte; Bislig Bay and Coastal waters of Cortez in Surigao del Sur; and Litalit Bay in Surigao del Norte. **Moreover, Coastal waters of Milagros in Masbate is now free of the toxic red tides.**

EDUARDO B. GONGONA
 BFAR National Director

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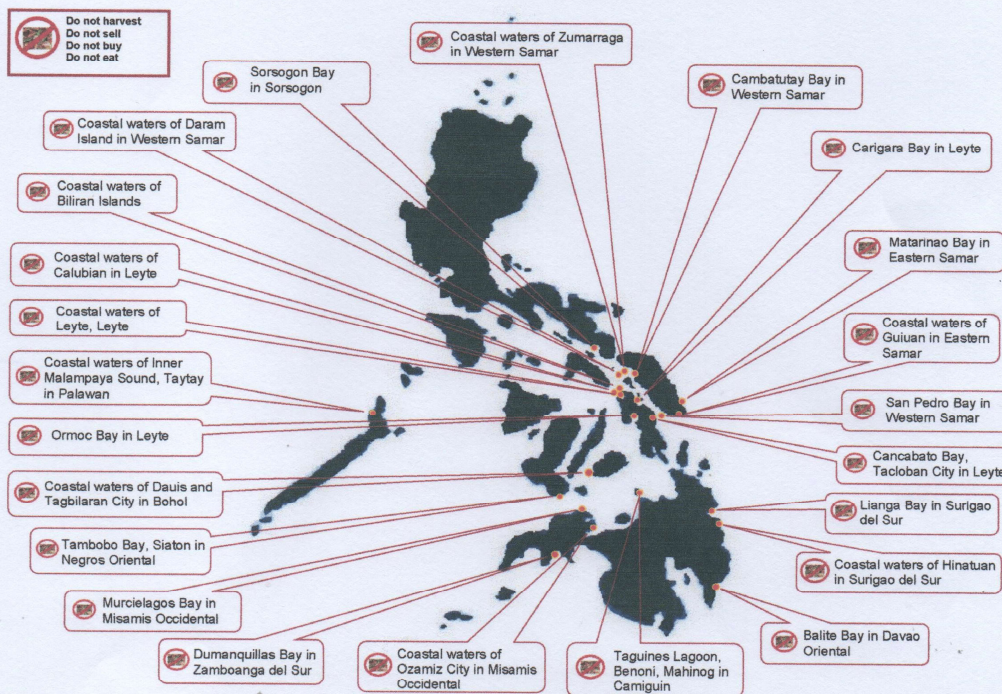


Figure 3.D.1. Shellfish Bulletin no. 2 Issued by BFAR in 2021 including Malampaya Sound in Taytay, Palawan.



Shellfish Bulletin No. 05
Series of 2021
 26 February 2021

Based on the latest laboratory results of the Bureau of Fisheries and Aquatic Resources (BFAR) and Local Government Units (LGUs), shellfishes collected at **Coastal waters of Inner Malampaya Sound, Taytay in Palawan; Sorsogon Bay in Sorsogon; Coastal waters of Daus and Tagbilaran City in Bohol; Tambobo Bay, Siaton in Negros Oriental; Coastal waters of Daran Island, Zumarraga, San Pedro and Cambatutay Bays in Western Samar; Coastal waters of Calubian, Leyte, Carigara Bay, Ormoc Bay and Cancabato Bay, Tacloban City in Leyte; Coastal waters of Biliran Islands; Coastal waters of Guian and Matarinao Bay in Eastern Samar; Dumanquillas Bay in Zamboanga del Sur; Balite Bay, Mati City in Davao Oriental; and Lianga Bay and Coastal waters of Hinatuan in Surigao del Sur** are still **positive** for paralytic shellfish poison that is beyond the regulatory limit. **Moreover, Murcielagos Bay (Sapang Dalaga and Baliangao) and Coastal waters of Ozamiz City in Misamis Occidental; and Taguines Lagoon, Benoni, Mahinog in Camiguin** are now **positive** for red tide toxin.



All types of shellfish and *Acetes sp.* or alamang gathered from the areas shown above are NOT SAFE for human consumption. Fish, squids, shrimps and crabs are safe for human consumption provided that they are fresh and washed thoroughly, and internal organs such as gills and intestines are removed before cooking.

The following areas continue to be **FREE from toxic red tides**: coastal waters of Cavite, Las Piñas, Parañaque, Navotas, Bulacan and Bataan (Mariveles, Limay, Orion, Pilar, Balanga, Hermosa, Oraai, Abucay and Samal) in Manila Bay; coastal waters of Bolinao, Anda, Alaminos, Sual and Wawa, Bani in Pangasinan; coastal waters of Pampanga; Masinloc Bay in Zambales; Honda and Puerto Princesa Bays, Puerto Princesa City in Palawan; coastal waters of Milagros and Mandaon in Masbate; Juag Lagoon, Matnog in Sorsogon; coastal waters of Gigantes Islands, Carles in Iloilo; coastal waters of Pilar, Panay, President Roxas and Roxas City in Capiz; Sapijan Bay (Ivisan and Sapijan in Capiz; Mambuquio and Camanci, Batan in Aklan); Altavas, Batan and New Washington in Batan Bay, Aklan; coastal waters of E.B. Magalona, Talisay City, Silay City, Bacolod City, Hinigaran and Victorias City in Negros Occidental; Siit Bay, Siaton and Bais Bay, Bais City in Negros Oriental; Irong-irong, Maqueda and Villareal Bays in Western Samar; Panguil Bay, Tanguib City in Misamis Occidental; Murcielagos Bay in Zamboanga del Norte; Coastal waters of Nasipit in Agusan del Norte; Bislig Bay and Coastal waters of Cortez in Surigao del Sur; and Litalit Bay in Surigao del Norte.

Commodore EDUARDO B. GONGONA, PCG (Ret.)
 BFAR National Director

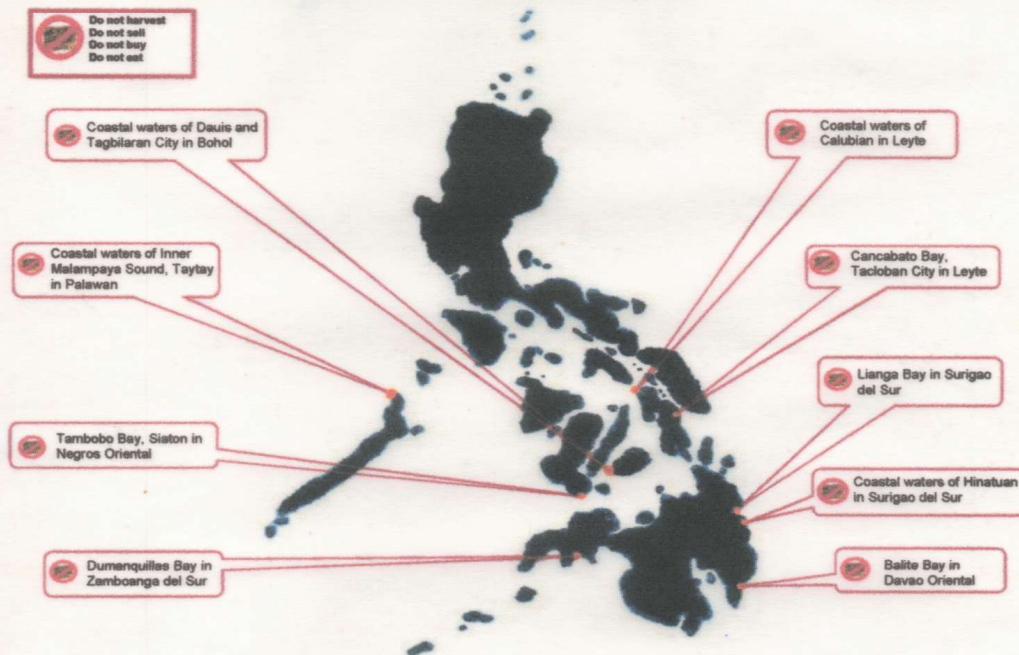


Figure 3.D.2. Shellfish Bulletin no. 5 Issued by BFAR in 2021 including Malampaya Sound in Taytay, Palawan.



Shellfish Bulletin No. 08
Series of 2021
 29 March 2021

Based on the latest laboratory results of the Bureau of Fisheries and Aquatic Resources (BFAR) and Local Government Units (LGUs), shellfishes collected at **coastal waters of Inner Malampaya Sound, Taytay in Palawan; coastal waters of Dauis and Tagbilaran City in Bohol; Tambobo Bay, Siaton in Negros Oriental; coastal waters of Calubian, and Cancabato Bay, Tacloban City in Leyte; Dumanquillas Bay in Zamboanga del Sur; Balite Bay, Mati City in Davao Oriental; and Lianga Bay and coastal waters of Hinatuan in Surigao del Sur** are still **positive** for paralytic shellfish poison that is beyond the regulatory limit.



All types of shellfish and *Acetes sp.* or alamang gathered from the areas shown above are NOT SAFE for human consumption. Fish, squids, shrimps and crabs are safe for human consumption provided that they are fresh and washed thoroughly, and internal organs such as gills and intestines are removed before cooking.

The following areas continue to be **FREE from toxic red tides**: coastal waters of Cavite, Las Piñas, Parañaque, Navotas, Bulacan and Bataan (Mariveles, Limay, Orion, Pilar, Balanga, Hermosa, Orani, Abucaay and Samal) in Manila Bay; coastal waters of Bolinao, Anda, Alaminos, Sual and Wawa, Bani in Pangasinan; coastal waters of Pampanga; Masinloc Bay in Zambales; Honda and Puerto Princesa Bays, Puerto Princesa City in Palawan; coastal waters of Milagro and Mandaon in Masbate; Sorsogon Bay and Juag Lagoon, Matnog in Sorsogon; coastal waters of Gigantes Islands, Carles in Iloilo; coastal waters of Pilar, Panay, President Roxas and Roxas City in Capiz; Sapián Bay (Ivisan and Sapián in Capiz; Mambuquio and Camanci, Batán in Aklan); Altavas, Batán and New Washington in Batán Bay, Aklan; coastal waters of E.B. Magalona, Talisay City, Silay City, Bacolod City, Hinigaran and Victorias City in Negros Occidental; Siit Bay, Siaton, and Bais Bay, Bais City in Negros Oriental; coastal waters of Daram Island, and Zumarraga, San Pedro, Cambatutay, Irong-Irong, Maqueda and Villareal Bays in Western Samar; coastal waters of Leyte, Carigara and Ormoc Bays in Leyte; coastal waters of Biliran Islands; coastal waters of Guiuan and Matarinao Bay in Eastern Samar; Panguil Bay, Tangub City in Misamis Occidental; Murcielagos Bay in Zamboanga del Norte; coastal waters of Nasipit in Agusan del Norte; Bislig Bay and coastal waters of Cortez in Surigao del Sur; and Litalit Bay in Surigao del Norte. **Moreover, Murcielagos Bay (Sapang Dalaga and Baliangao) and coastal waters of Ozamiz City in Misamis Occidental; and Taguines Lagoon, Benoni, Mahinog in Camiguin are now free of the toxic red tides.**

Commodore EDUARDO B. GONGONA, PCG (Ret.)
 BFAR National Director

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Figure 3.D.3. Shellfish Bulletin no. 8 Issued by BFAR in 2021 including Malampaya Sound in Taytay, Palawan.

Table 3.D.2. Fish Kill Events in the Philippine Waters of SCS-LME (Yniguez et al., 2021); San Diego-McGlone et al., 2024).

Year	Site	Number of Events
2002	Bolinao-Anda, Pangasinan	2
	Balayan Bay, Batangas	1
	Eastern side of Luzon	1
	San Antonio, Zambales	1
2003	Bolinao-Anda, Pangasinan	1
	Dagupan City, Pangasinan	1
	Vigan City, Ilocos Sur	2
	Sto. Tomas, La Union	1
2004	Bolinao-Anda, Pangasinan	1
	Sto. Tomas, La Union	1
2005	West coast of Palawan	1
	Dagupan City, Pangasinan	2
	Binmaley, Pangasinan	1
	Bolinao-Anda, Pangasinan	1
	Bani, Pangasinan	1
2007	Bolinao-Anda, Pangasinan	1
2010	Bolinao-Anda, Pangasinan	1
2011	Bolinao-Anda, Pangasinan	1
2013	Anda, Pangasinan	1
2015	Bani, Pangasinan	1
	Bolinao-Anda, Pangasinan	1
	Subic, Zambales	1
2016	Bolinao-Anda, Pangasinan	1
	Orion, Bataan	1
2017	Sual, Pangasinan	1
	Vigan City, Ilocos Sur	1
	Obando, Bulacan	1
	Bulacan	1
2018	Anda, Pangasinan	1
	Bolinao, Pangasinan	1
	Bani, Pangasinan	1
	San Vicente, Ilocos Sur	1
	Bulacan, Manila Bay	1
2019	Sual, Pangasinan	1
	Las Piñas-Parañaque	1
2020	Dagupan City, Pangasinan	1
	San Fernando City, La Union	1
	Nasugbu, Batangas	1
2021	San Fabian, Pangasinan	1
	San Vicente, Ilocos Sur	1
	Sta. Catalina, Ilocos Sur	1
	Dagupan City, Pangasinan	1
2022	San Vicente, Ilocos Sur	1
	Obando, Bulacan	1
2023	Sto. Tomas, La Union	2
	Cañacao Bay, Cavite City	1
2024	Bolinao-Anda, Pangasinan	1
	Nasugbu, Batangas	1
	Magsaysay, Occidental Mindoro	1
2025	San Juan, La Union	1
	Obando, Bulacan	1

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I										
	1	2003	Pangasinan	Dagupan City	Pugaro & Salapingao	Dissolved Oxygen depletion	Milkfish	Not reported	Not reported	Conduct regular monitoring and technical advice/assistance on Good Aquaculture Practices to affected fishfarmers.
	2	5/29/2003	Ilocos Sur	Vigan City	Pantay River, Brgy. Mindoro	-Water is murky and color reddish brown - DO is 1.5 mg/L	Milkfish	Not reported	Not reported	Recommended the transfer of tilapia to safer fishponds to prevent further mortality and the immediate opening of the estuary to flush out polluted water to the sea to prevent further fishkill in the area
	3	6/2/2003	Ilocos Sur	Vigan City	Pantay Daya	- Water has rotten odor, color turned blackish - DO is 0.01mg/L	Tilapia	Not reported	Not reported	Recommended the transfer of tilapia to safer fishponds to prevent further mortality and the immediate opening of the estuary to prevent further fishkill
	4	11/21/2003	La Union	Sto. Tomas	Cabaroan	Presence of parasites (kuto) which was sticking to the flesh and gills of the fish	Grouper, Sigamid, Prawn	Not reported	Not reported	Ocular investigation was conducted by Fish Health Officer. Obtained fish, water and soil samples for laboratory analyses. Technical advice on affected fishfarmers.
	5	02/04-09/2004	La Union	Sto Tomas	Casantaan (Mariculture Zone Project)	-Presence of white color at back of the fish -Fin rot, skin abrasion -Cork screw swimming pattern	Milkfish	Not reported	Not reported	Fish and water samples were collected for further analysis
	6	5/24/2005	Pangasinan	Dagupan and Binmaley		-Dissolved Oxygen depletion and overstocking	Milkfish, eels, tilapia, shrimp, sapsap, crabs, spade fish	Not reported	Not reported	BFAR RFO I staff with OPAG personnel conducted water quality monitoring. Water/plankton samples were collected for further analysis at BFAR CO.
	7	10/25/2005	Pangasinan	Dagupan City	Calmay Ilocano	- Unregulated water flow/circulation	Milkfish	5,000 fingerlings	Not reported	Ocular investigation was conducted by Fish Health Officer. Obtained fish, and water samples for laboratory analyses. Technical advice on affected fishfarmer.
	8	5/30/2006	Pangasinan	Bani	Masidem	-low dissolved oxygen -dominated with 100% of Plankton composition by Scripsiella trochoidea	Kabasi Anodontostoma chacunda	Not reported	Not reported	Submitted samples to the Marine Biotoxin Unit, BFAR Central Office
	9	04/02-05/2013 (Monitoring)	Pangasinan	Dagupan City	Tococ	-White coloration	Milkfish	Not reported	Not reported	Forced harvest of affected fishpond and fishpen
	10	5/24/2013	Pangasinan	Anda	Siapar	-Over stocking -Natural upwelling -Excessive plankton growth -Decaying organic matter	Milkfish	Not reported	Not reported	
	11	4/20/2015	Pangasinan	Bani	Banog Norte	- low dissolved oxygen (0.04-1.19 mg/l)	Assorted fish (shrimp, goby, etc.)	270kgs	Not reported	collected from Bani River, no specific farm affected
	12	04/26-30/2015	Pangasinan	Bolinao		- low dissolved oxygen (0.02mg/l)	Assorted fish (shrimp, goby, etc.)	2,300MT	P218.50M	
	13	5/21/2016	Pangasinan	Anda	Siapar	- low dissolved oxygen (1.71mg/l) - over stocking	milkfish	affected size: post fingerlings, 250g/piece		
	14	10/1-2/2017	Pangasinan	Sual		- low dissolved oxygen (0.55mg/l) - over stocking	Milkfish	- 2 fishcages operator with a total of 43 fish cages (18x18Norwegian cage) was greatly affected - affected size: fingerlings, 350-550g	30.7Million	

Figure 3.D.4a. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I	15	05/25-26/2017	Ilocos Sur	Vigan City	San Pedro	- over stocking - low water level - restricted water movement -	Milkfish and tilapia	4MT (tilapia) 2MT (milkfish) Size of cage: 100 sq. m. 35 fish cage operators affected	Not reported	
	16	2/27/2018	Ilocos Sur	San Vicente		- overstocking		Not reported	Not reported	Update and amend certain prohibitions of the Municipal Fishery Ordinance, to include: allocations of proper distances between cages, setting of stocking densities (maximum of 40pcs/m ³) per cage operator, feeding management (5-10% ABW/day), use of floater feeds only, cage size regulation, Enforcement of permitting system (allowable number of cages/operator); and Conduct of Orientation and Training on Good Aquaculture Practices to fish cage/pen operators.
	17	5/7/2018	Pangasinan	Bani		- low water level - low dissolved oxygen		Not reported	Not reported	LGU seriously consider clearing the river of structures obstructing water flow, and desiltation. Likewise, fishpond operators must observe good aquaculture practices (proper waste disposal), and a monitoring body be established to regularly monitor water quality condition.
	18	05/29-31/2018	Pangasinan	Anda		- Waters along Catubig turned rusty in color combined with foul odor - Fishy/foul odor - various species of crab begun to move out of the water towards the ground - "tribunada" struck some parts of Anda particularly along Catubig area - low dissolved oxygen - Temperature is high while Salinity, pH and nitrite are within the desirable level for fish culture.	Milkfish	55,000pcs, 100% mortality	Not reported	Recommended one month Moratorium on stocking and/or issuance by DENR of Cease-and-Desist Order, Imposition of ECC as a requirement for Mariculture, Permitting by LGU and unconditional enforcement of "NO FISHPEN" Policy
	19	05/29-31/2018	Pangasinan	Bolinao		- "Gataw" occurs along areas where the passing of "milky-white" colored water - low dissolved oxygen - Ammonia levels are in sub-lethal condition. - Temperature is high while Salinity, pH and nitrite are within the desirable level for fish culture.		1,030,000 Fingerlings (pcs) 965.09MT	Not reported	Recommended one month Moratorium on stocking and/or issuance by DENR of Cease-and-Desist Order, Imposition of ECC as a requirement for Mariculture, Permitting by LGU and unconditional enforcement of "NO FISHPEN" Policy
	20	9/25/2019	Pangasinan	Sual		- low level of dissolved oxygen at 10m depth - ammonia levels are in sub-lethal condition - plankton identification and count showed presence of Amnesic Shellfish Poisoning (ASP)	Milkfish	Not reported	Not reported	Operators to ensure regular collection of dead fishes by their cage workers, LGU to ensure and monitor proper disposal of dead fishes and wastes in the designated disposal facility, stocking density and proper feeding management be strictly followed, LGU to strictly enforce ordinance and development plan relative to the capacity and distancing of structures.

Figure 3.D.4b. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I	21	04/25-29/2020	Pangasinan	Dagupan City		- high temperature - low dissolved oxygen - lethal level of ammonia	Milkfish, siganids and groupers	Not reported	Not reported	Recommended; A. For Farm Operators - operators to be on guard 24/7 to monitor of their cultured stocks, strictly follow the recommended stocking density and report immediately to LGU any abnormal situation during farm operation and equip farms with basic water quality monitoring equipment. B. For LGU - strictly implement "NO FISHPEN POLICY", advice operators to adhere to Good Aquaculture Practices and require all aquaculture farms to register with BFAR. C. BFAR 1 action on the repeated fish kill - conduct fish kill investigations (preliminary and final), submitted report o the DA, OCD, BFAR I for damage report and prepared and submitted rehab plan.
	22	11/5-6/2020	La Union	San Fernando City		- simultaneous overflowing of water from the polluted creeks		Not reported	Not reported	Recommended that to re-direct or re-channel the flow of water in the canal not directly to the sea, to conduct regular water quality monitoring, to advice the residents not to consume dead fishes and request DENR to check compliances of the establishment in the area re: discharges.
	23	1/28/2021	Pangasinan	San Fabian		- low level of dissolved oxygen - lethal level of ammonia - overcrowding of stocks in one unit	Milkfish	Cultured Milkfish (100,000 pcs)	Not reported	Strict implementation of Municipal Fishery Ordinance for the establishment of fishery structures and good aquaculture practices, capacitate operators with water quality monitoring instruments/equipment/kits to regularly monitor water quality, report immediately any unusual mortalities/events involving cultured stocks and observe proper disposal of dead milkfish.
	24	5/31/2021	Ilocos Sur	San Vicente		- critical level of dissolved oxygen - high temperature - lethal level of ammonia	Milkfish, Siganid and Tilapia		Tilapia - 9.27 million Milkfish - 747 thousand Siganid - 3.4 million	Enactment/updating of Municipal Fishery Ordinance to include permitting system, aquaculture activities, zonation, size regulation, stocking density, feeding, among others; conduct of regular water quality monitoring considering the intensive aquaculture activities in the area; observance and training of operators/caretakers of Good Aquaculture Practices; procurement of water quality equipment.
	25	5/31/2021	Ilocos Sur	Sta. Catalina		- critical level of dissolved oxygen - high temperature - lethal level of ammonia	Tilapia and Milkfish		Tilapia - 2.1 million Milkfish - 264 thousand	Enactment/updating of Municipal Fishery Ordinance to include permitting system, aquaculture activities, zonation, size regulation, stocking density, feeding, among others; conduct of regular water quality monitoring considering the intensive aquaculture activities in the area; observance and training of operators/caretakers of Good Aquaculture Practices; procurement of water quality equipment.
	26	5/20/2021	Pangasinan	Dagupan City		- high temperature - low water level		665,685 pcs (fry/fingerlings, juvenile, marketable)	Total Loss (19 million)	Recommended that need re-validation to determine actual damage losses in the area.

Figure 3.D.4c. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I										
	27	1/24/2022	Ilocos Sur	San Vicente		- critical level of dissolved oxygen - lethal level of ammonia - 40% of the total river area was occupied for cage culture with no proper cage spacing	Milkfish and Tilapia	Not reported	Not reported	Enactment/updating of Municipal Fishery Ordinance to include permitting system, aquaculture activities, zonation, size regulation, stocking density, feeding, among others; conduct of regular water quality monitoring considering the intensive aquaculture activities in the area; observance and training of operators/caretakers of Good Aquaculture Practices; procurement of water quality equipment.
	28	2/20/2023	La Union	Sto. Tomas		- smell, and species affected from the wild, it is possible that the water during the incident is contaminated with pesticides	Shrimp, eel, serew, talakitok, goby, oysters	Not reported	Not reported	The technician of the pond be equipped with technical knowhow regarding pond preparation and management to improve aquaculture practices; PFO personnel to be aware of the protocol during fishkill investigation; and an IEC be conducted to all aquaculture operators to equip them with the appropriate knowledge.
	29	3/10/2023	La Union	Sto. Tomas		- salinity is higher (31-25 ppt) - no assistance yet or projects received from the government			Not reported	LGU must declare the proposed site for the MSN project; provide marker buoys for the demarcation of the proposed site; and orientation for beneficiaries prior to turn-over of the project.
	30	4/19/2024	Pangasinan	Natividad		- no pond preparation and fertilization was conducted since the start of operation - overstocking - no water quality monitoring - fishes were not fed on the onset of mortality	Tilapia	Not reported	Not reported	Practice pond preparation, install nets in the pond gates to prevent entry/transfer of predators, trim the grasses in the dike and surroundings of the pond and for the operator participate trainings on fish culture.
	31	4/26/2023	Ilocos Sur	San Ildefonso		- to critical levels of water quality parameters associated with turbid, oily, and stinky water - low dissolved oxygen - absence of water movement and the presence of macro aquatic plants in the production area		4.75MT	Not reported	The LGU should procure water quality equipment for monitoring purposes and conduct of regular monitoring of the aquaculture area; operators must observe Good Aquaculture and to be vigilant and observant on the status of cultured stocks; unwanted aquatic plants adjacent to the fish cages should be removed throughout the culture period; collect all dead fish and buried, and lift the cages with no stocks to restore the quality of the water and conduct emergency harvest if needed.
	32	6/5/2024	Pangasinan	Anda and Bolinao		- turbidity - low of quality water monitoring - low of dissolved oxygen - high ammonia levels	Milkfish	Not reported	Not reported	There is no FISH KILL incident, the incident is identified as isolated fish mortalities since only 14% of the total fish cage units in the area are affected and LGU Anda, despite undermanned, continuously monitors its fish landing port
	33	2/18/2025	La Union	San Juan		- slow movement of water - low dissolved of oxygen - above desirable of monia-nitrogen	Milkfish	3000 pcs or 75 pcs/m2	Not reported	All operators, feeders, and caretakers of fishponds, fishpen, and fishcages must undergo orientation on the Good Aquaculture Practices (GAQP). LGU is advise to regularly conduct water quality monitoring and declare feasible area as an aquaculture zone.

Figure 3.D.4d. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	number/volume of Affected	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION II	1	5/8/2017	Isabela	Mallig	San Jose	High level of ammonia	Tilapia	200 pcs.	Not Reported	Water Quality Analysis/Parasitological Analysis
	2	6/3/2017	Batanes	Itbayat	Kawaywan Lake	Dissolved Oxygen Depletion/ Open Stocking	Tilapia	90%	Not Reported	Water Quality Analysis/Parasitological Analysis/ Aflatoxin Test
	3	6/19/2017	Quirino	Aglipay	Pinalpad	overstocking	Tilapia	40%	Not Reported	Water Quality Analysis/Parasitological Analysis
	4	7/4/2017	Cagayan	Peñablanca	Cabasan	Very High Stocking density	Tilapia	20%	Not Reported	Water Quality Analysis/Parasitological Analysis/
	5	7/5/2017	Cagayan	Sta.Ana	Rapuli	high level of ammonia/high level of salinity	Tilapia	10%	Not Reported	Water Quality Analysis/Parasitological Analysis/ Microbial Analysis/ Fish Necropsy
	6	7/5/2017	Cagayan	Sta.Ana		high level of ammonia/high level of salinity/ high level of Carbon dioxide	Tilapia	10%	Not Reported	Water Quality Analysis/Parasitological Analysis/ Microbial Analysis/ Fish Necropsy
	7	8/18/2017	Isabela	Cauayan	Nungnungan	high level of ammonia, low level of DO, Overstocking	Tilapia	200 pcs.	Not Reported	Water Quality Analysis/Parasitological Analysis
	8	8/18/2017	Isabela	Cauayan City	Nungnungan	high level of ammonia, low level of DO, Overstocking	Tilapia	200 pcs.	Not Reported	Water Quality Analysis/Parasitological Analysis
	9	10/9/2017	Cagayan	Sta. Teresita		Formation of Molds in Organic Feeds fed with crabs	Poly culture of Bangus and Crabs	100%	Not Reported	Water Quality Analysis
	10	11/10/2017	Cagayan	Aparri	Aparri Farm Station	high level of ammonia/ Abrupt change in water	Tilapia	55%	Not Reported	Water quality analysis/Microbial Analysis/Fish Examination
	11	11/14/2017	Nueva Vizcaya	Solano	Galima	low DO level/ over stocking	Tilapia	600%	Not Reported	Water quality analysis
	12	11/28/2017	Cagayan	Allacapan		high level of ammonia/ Abrupt change in water/ Open Stocking	Tilapia	30%	Not Reported	Water quality analysis
	13	6/6/2018	Isabela	Mallig	Victoria	Overstocking, Thermal destratification/overturn, Low DO, high level Ammonia Nitrogen	Tilapia	50%	Not Reported	Onsite water quality analysis, Flushing of pond is recommended
	14	6/12/2018	Isabela	San Mariano	Sta. Filomena	Oxygen depletion, Overstocking	Tilapia	70%	Not Reported	Onsite water quality analysis, transferring of remaining stocks is recommended
	15	1/21/2020	Isabela	Sta. Maria	Buena Vista	Presence of Fish Louse	Koi Carp	30%	Not Reported	Short Salt Bath and Lond Salt bath
	16	3/25/2020	Isabela	Sta. Maria	Sitio Bayabo	High Stocking Density	Tilapia	5%	Not Reported	Water Quality Analysis, Fish Examination
	17	8/24/2021	Isabela	Sta. Maria	Buena Vista	High Stocking Density	Tilapia	50%	Not Reported	Onsite water quality analysis, transferring of remaining stocks is recommended
	18	2/22/2022	Isabela	Delfin Albano		High Stocking Density, Overturn Caused by heavy rain	Tilapia	2.76%	Not Reported	Onsite water quality analysis, transferring of remaining stocks is recommended
	19	3/14/2022	Isabela	Delfin Albano	Villa Pereda	High Stocking Density, Overturn Caused by heavy rain, Pesticide Toxicity (suspected)	Tilapia	100.00%	Not Reported	Onsite water quality analysis, transferring of remaining stocks is recommended
	20	4/26/2023	Isabela	Sta. Maria	Buenavista	Low concentration of Dissolved Oxygen	Tilapia	1,140 pieces	Not Reported	Conducted water quality analysis, Recommendations of installing a drainage outlet for each pond, removal of organic matter, and attending training on Fish Health Management and Tilapia Pond Management was given.
	21	5/25/2023	Isabela	Cabagan		Low concentration of Dissolved Oxygen, High concentration of Ammonia Nitrogen and Carbon Dioxide, Acidic (low pH) condition.	Catfish	2,000 kg in harvestable size	Not Reported	Water quality analysis was conducted. Recommendations such as installation and securing safe source of water, reconstruction of pond layout, and controlling growth of aquatic vegetation were given.
	22	6/19/2023	Isabela	Quirino	Luna	High levels of Ammonia Nitrogen and low Dissolved Oxygen	Tilapia	600 pieces of larger fish	Not Reported	Conducted water quality analysis, recommended to follow stocking density of 5pcs per square meter, replenish pond water, proper feeding to avoid build-up of toxic ammonia, and cleaning of ponds regularly and removal of dead fish.
	23	6/26/2023	Cagayan	Solana	Sampaguita	Critical level of Dissolved Oxygen, toxic concentration of Ammonia-Nitrogen, and Nitrite-Nitrogen.	Tilapia	> 200 kg	Not Reported	Conducted on-site water quality analysis. Recommendation of immediate harvesting of remaining stocks, improve water system, and consultation to the bureau for assistance in proper pond construction were given.
	24	7/24/2023	Cagayan	Tuao East	Naruangan	Low Dissolved Oxygen, High Ammonia-Nitrogen, Alkalinity, and Carbon Dioxide levels.	Catfish	18 pieces	Not Reported	On-site Water Quality Analysis was conducted. Recommendations such as strict monitoring of pond, maintaining good water quality, proper stocking density of 8-10 pcs of catfish per m2, removal of unwanted plants, and practice of proper fish pond prep were given.

Figure 3.D.5a. Region II, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	number/volume of Affected	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION II										
	25	7/31/2023	Cagayan	Tuao	Mambacag	Abnormal levels of Ammonia-Nitrogen	Tilapia	825 pieces	Not Reported	Conducted On-site water quality analysis and parasitological examination. Recommendation of disposition and proper collection of dead fish from ponds, keeping animals in separate area, and conducting water exchange in the ponds were given.
	26	8/1/2023	Cagayan	Lasam	Finugo	High levels of Ammonia Nitrogen and low Dissolved Oxygen	Tilapia	30 kg	Not Reported	Conducted on-site water quality analysis and parasitological examination. Recommendations such as conducting water exchange in the ponds, reducing feeding frequency during rainy days, removal of natural debris in the pond, and proper collection and disposal of dead fish were given.
	27	8/24/2023	Cagayan	Iguig	Garab	Low Dissolved Oxygen	Tilapia	10	Not Reported	
	28	2/15/2024	Cagayan	Solana	Sampaguita	High stocking density	Tilapia	98	Not Reported	on site water quality analysis, ocular inspection and parasitological analysis were conducted
	29	4/30/2024	Cagayan	Solana	Nangalisan	No adequate supply of water thus water level is only one meter, Low concentration of dissolved oxygen high concentration of Ammonia Nitrogen and Nitrite nitrogen level	Tilapia		Not Reported	ocular inspection, water quality analysis and recommended to follow stocking density of 5pcs per square meter
	30	5/20/2024	Cagayan	Alcala	Pussian	High concentration of Ammonia Nitrogen	Tilapia		Not Reported	on site water quality analysis, ocular inspection
	31	5/21/2024	Cagayan	Alcala	Carallangan	High concentration of Ammonia Nitrogen	Tilapia	100	Not Reported	on site water quality analysis, ocular inspection
	32	6/17/2024	Isabela	Ramon	Aguinaldo	Low water levels due to insufficient supply from the irrigation, critically low dissolved oxygen levels, heavy rainfall	Tilapia	2,700	Not Reported	ocular inspection, on-site water quality analysis, and necropsy was conducted
	33	6/18/2024	Isabela	Quezon	Isabela		Ulang		Not Reported	
	34	7/4/2024	Cagayan	Peñablanca	San Roque	Water level is low, pond water exhibited a brown-green color and was noticeably muddy.	Tilapia		Not Reported	On-site water quality analysis, ocular inspection and water microbial analysis
	35	7/12/2024	Isabela	Quezon	Estrada	Rainfall occurrence caused thermal de-stratification resulting in low oxygen levels	Tilapia	300	Not Reported	On-site water quality analysis, ocular inspection
	36	7/12/2024	Isabela	Quezon	Barucboc	Rainfall occurrence caused thermal de-stratification resulting in low oxygen levels	Tilapia	500	Not Reported	On-site water quality analysis, ocular inspection
	37	7/12/2024	Isabela	Quezon	Barucboc	Rainfall occurrence caused thermal de-stratification resulting in low oxygen levels	Tilapia	500	Not Reported	On-site water quality analysis, ocular inspection
	38	7/15/2024	Cagayan	Piat		Water color is noticeably muddy, depth is less than one meter, low dissolved oxygen levels	Tilapia	120	Not Reported	On-site water quality analysis, ocular inspection
	39	2/7/2025	Cagayan	Solana		ammonia and carbon dioxide is above the normal	tilapia	100%	Not Reported	conduct water quality analysis
	40	3/14/2025	Isabela	Marranao SWIP, San Mariano	Marranao SWIP	ammonia is too high	tilapia	9%	Not Reported	ocular inspection, water quality analysis, collected tilapia samples for TILV analysis and parasitological analysis
	41	3/27/2025	Cagayan	Amulung	Dadda	carbon dioxide too high	catfish	80%	Not Reported	ocular inspection, water quality analysis, recommended water exchange and increase level of water in the tank, collection and disposal of dead fingerlings
	42	4/30/2025	Isabela	Cordon	Taliktik	overstocking, low DO due to thermal destratification, high ammonia level	tilapia	70-80%	Not Reported	ocular inspection, water quality analysis, recommended not to cover stock and follow the stocking density
	43	5/22/2025	Isabela	Quezon	Barucboc	above normal levels of alkalinity, CO2, and hardness. below normal level of DO	tilapia	8%	Not Reported	ocular inspection, water quality analysis, gross morphology
	44	5/30/2025	Cagayan	Ballesteros	Nararagan	overstocking, low DO due to thermal destratification	tilapia	80%	Not Reported	on-site water quality analysis, gross morphological analysis, ocular inspection, microbiological analysis
	45	7/7/2025	Cagayan	Rizal	Duyun	fish gasping on the surface	tilapia	8%	Not Reported	on site water quality analysis, ocular inspection
	46	7/10/2025	Cagayan	Amulung	Nagsabaran	low dissolved oxygen	tilapia	80%	Not Reported	on site water quality analysis, ocular inspection

Figure 3.D.5b. Region II, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION III	1	9/23/2014	Bulacan	Balagtas	Panginay	• Extremely Low Dissolved Oxygen • Extremely High Unionized Ammonia • Floods brought by Typhoon Mario	-	-	Not Reported	-
	2	11/3/2014	Bataan (San Juan River)	Samal	Daan Bago	Extremely Low Dissolved Oxygen	Tilapia Gloria	-	Not Reported	-
	3	1/23/2015	Zambales	Subic	Nagyantok	Extremely high levels of Total Unionized Ammonia		-	Not Reported	Alleged Fishkill No mortalities found upon investigation
	4	7/22/2015	Pampanga River	Candaba/Macabebe/Masantol		Extremely low dissolved oxygen. Possible overturn brought about by sudden heavy rains	Freshwater fishes	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	5	8/28/2015	Bulacan	Balagtas	Panginay	Flood due to Heavy Rains	Tilapia	-	Not Reported	Reported late Mortalities were disposed upon investigation
	6	8/1/2016	Bataan	Orion	Capunitan	Possible overturn brought about by sudden heavy rains in the late afternoon	Marine Fishes, shrimps, crabs	-	Not Reported	Reported late, no mortalities found upon investigation. Conducted on-site fish kill investigation and water quality monitoring.
	7	1/2/2017	Bulacan	Obando		Extremely Low Dissolved Oxygen	Milkfish	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	8	7/14/2017	Pampanga	Lubao		Extremely low dissolved oxygen	Tilapia	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	9	7/14/2017	Bulacan (Calumpit River)			Possible overturn brought about by sudden heavy rains in the late afternoon	Freshwater fishes	-	Not Reported	Reported late, no mortalities found upon investigation. Conducted on-site fish kill investigation and water quality monitoring.
	10	7/15/2017	Pampanga	Guagua		Extremely low dissolved oxygen	Tilapia	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	11	7/18/2017	Pampanga	Minalin		Extremely low dissolved oxygen	Tilapia	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	12	9/21/2017	Pampanga (Delta River)	Masantol/Apalit/Macabebe		Extremely Low Dissolved Oxygen	Freshwater fishes Kanduli, common carps, big head carps, ulang tilapia, ayungin	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	13	5/16/2022	Bulacan	Obando	Tawiran	Oxygen depletion due to the eutrophication and intense heat then followed by days of heavy rains which lead to a sudden drop of temperature		-	Not Reported	• on-site assessment and investigation • water sample tested for physico-chemical parameters • interview with the locals to gather information on what actually happened on that day and the days prior to the incident
	14	8/31/2023	Tarlac	Concepcion	Dungan	Poor water quality aggravated by the sudden change of temperature brought by the changing weather patterns	Tilapia	atleast 5 metric tons	Not Reported	• onsite water quality assessment • water sample tested for physico-chemical parameters • fish sample tested for TILV (found NEGATIVE)
	15	4/21/2025	Bulacan	Obando		Oxygen depletion due to the eutrophication and intense by fluctuating temperature brought about the light rain showers before the alleged fishkill incidence. Lowtide also aggravated the stratification by stirring up the sediments which further depletes the oxygen.		-	Not Reported	• on-site assessment and investigation • water sample tested for physico-chemical parameters • interview with the locals to gather information on what actually happened on that day and the days prior to the incident

Figure 3.D.6. Region III, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported [mm/dd/yy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION IV-A										
	1	2/13/2020	Batangas	Mataas na kahoy	Barangay Lumanglipa	Oxygen depletion as water level decreased in the area after Taal volcano eruption.	Sardinella tawilis	0.22 MT	No estimated value of loss (Php) declared by the LGU	BIFTOS <ul style="list-style-type: none"> Conducted on-site fish kill investigation and water quality monitoring in the affected areas on February 13, 2020 and provided advisories afterwards. 2. Advised the residents and fisher folks not to eat and market those dead tawilis fishes seen from their area but instead, collect and bury them properly.
	2	06/20/20	Laguna	San Pablo	Sampaloc Lake	Phosphate levels in the samples exceeded the acceptable limits. The presence of external parasites such as Trichodina spp. and Gyrodactylus spp. indicated parasite infestation. Growth on blood agar exhibited characteristics consistent with Streptococcus spp.	Tilapia	16.5 MT	Php 1,500,000.00	*RFL <ul style="list-style-type: none"> Interview of some cage operators about common husbandry practices of rearing caged tilapia in Sampaloc Lake. Conducted on-site physical and chemical water quality testing. Collected water samples for microbiological analysis. Collected moribund tilapia samples for disease diagnosis.
	3	6/22/2020	Batangas	Agoncillo	Barangay Bilibinwang and Bañaga	Oxygen depletion due to heavy rain, sudden change of weather and temperature.	Tilapia	2 MT	*No estimated value of loss (Php) declared by the LGU.	BIFTOS <ul style="list-style-type: none"> Conducted on-site fish kill investigation and water quality monitoring in the affected areas on June 23, 2020 and provided advisories afterwards. Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest. Advised fish cage operators and caretakers to bury their stocks in the designated mortality pits and don't just throw outside the fish cages and lake water.
	4	7/15/2020	Batangas	Agoncillo	Barangay Bilibinwang and Bañaga	Oxygen depletion due to sudden change in weather (intense heat followed by heavy rains brought about by strong hanging-habagat).	Tilapia	40 MT	*No estimated value of loss (Php) declared by the LGU.	BIFTOS <ul style="list-style-type: none"> Conducted on-site fish kill investigation and water quality monitoring in the affected areas on July 16, 2020 and provided advisories afterwards. Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest and refrain temporarily from feeding their stocks.
	5	7/29/2020	Batangas	Nasugbu	Palico River	high ammonia and phosphate levels may cause algal blooms or heavy plant growth that can be detrimental to the fish and other aquatic life. Likewise, oxygen is consumed as ammonia is oxidized (nitrification), and low oxygen levels increase ammonia levels by inhibiting nitrification.	Igat, Dalag, Kitang, Sugpo, Hipon, Sapsap, Aligasin, Dangat, Buwan-buwan, Managat, Biya and Tilapia	500 kg	Affected 94 registered fisher folks who are all members of Bucana Fisherfolks Association	RFL <ul style="list-style-type: none"> Conducted interview of some fisher folk and residents. Conducted on-site physical and chemical water quality testing. Collected water samples for microbiological analysis. Collected moribund fish samples for disease diagnosis.

Figure 3.D.7a. Region IV-A, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported [mm/dd/yy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION IV-A										
	6	8/4/2020	Batangas	Laurel	Barangay Gulod, Balakilong and Leviste	Oxygen depletion due to sudden change in weather (calm, hot and dry weather followed by heavy rains brought about by strong hanging-habagat).	Tilapia Bangus	290 MT 5 MT	*Php 23,857,500.00 Php 600,000.00	BIFTOS <ul style="list-style-type: none"> Conducted on-site fish kill investigation and water quality monitoring in the affected areas on August 3, 2020 and provided advisories afterwards. Conducted post-fish kill water quality monitoring on August 4, 2020. Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest. Advised fish cage operators and caretakers to bury their stocks in the designated mortality pits and don't just throw outside the fish cages and lake water.
	7	9/28/2020	Rizal	Jalajala	Laguna Lake	There was an observed proliferation of water lilies and a significant increase in the green coloration of the water, indicating possible algal presence.	Bangus	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	*RFL <ul style="list-style-type: none"> Conducted interview of some fisher folk and residents. Identified 6 sampling sites and Conducted on-site physical and chemical water quality testing. Collected water samples for microbiological analysis. Collected moribund fish samples for disease diagnosis.
	8	9/30/2020	Batangas	Agoncillo	Barangay Balakilong, Laurel and Brgy. Bañaga, Brgy. Bilbinwang	Oxygen depletion due to sudden change in weather (calm, hot and dry weather followed by heavy rains).	Tilapia	20 MT	*No estimated value of loss (Php) declared by the LGU.	BIFTOS <ul style="list-style-type: none"> Conducted on-site fish kill investigation and water quality monitoring in the affected areas on September 30, 2020 and provided advisories afterwards. Conducted post-fish kill water quality monitoring on October 1-2, 2020. Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest. Advised fish cage operators and caretakers to bury their stocks in the designated mortality pits and don't just throw outside the fish cages and lake water.
	9	3/11/2022	Laguna	San Pablo City	Calibato Lake	Typhoon	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	RFL Conducted Laboratory Analysis, Advised Locals and LGU's, Created Fish Kill Incidence Report
	10	12/27/2022	Laguna	San Pablo City	Calibato Lake	Sulfur Upwelling	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	Conducted Laboratory Analysis, Advised Locals and LGU's, Created Fish Kill Incidence Report
	11	12/27/2022	Laguna	San Pablo City	Sampaloc Lake	Sulfur Upwelling	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	Conducted Laboratory Analysis, Advised Locals and LGU's, Created Fish Kill Incidence Report
	12	01/23/2023	Laguna	Los Baños	Brgy. Bambang	High Levels of Ammonia	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	Conducted Laboratory Analysis to determine the cause of fish kill and informed the Local Government Units.
	13	7/6/2023	Quezon	Lucena City	Iyam River	Low Dissolved Oxygen and High levels of Ammonia	Tilapia & Other unidentified species	200kg	No estimated value declared by the LGU	Conducted Laboratory Analysis and informed the Provincial Fisheries Office of Quezon about the result
	14	1/9/2023	Quezon	Dolores	Farmko Drawout Hatchery	High Levels of Ammonia	Pangasius	No estimated value provided by the farm owner	No estimated value provided by the farm owner	Informed the owners of the farm regarding the results and provided advice for maintaining the water quality
	15	4/15/2024	Batangas	Nasugbu	Sitio Hulo, Brgy. Calayo	Low Dissolved Oxygen and Harmful Algal Bloom	Eel, Puffer Fish & Other unidentified fish species			

Figure 3.D.7b. Region IV-A, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported [mm/dd/y]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION IV-B										
	1	4/2/2024	Occidental Mindoro	Magsaysay	Laste	Ice-ice, pitting, algae in seaweeds, and aquatic animal grazing on seaweeds	Seaweeds	1000 rumbay	Php 450,000	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collected seaweeds samples
	2	9/26/2024	Oriental Mindoro	Bansud	Salcedo	Dissolve oxygen depletion due to overstocking	Tilapia (juvenile)	1000 pcs tilapia	Php 3,750	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collected live fish samples (no clinical signs) 5. Conducted parasitology 6. Collected another set of fish samples for VNN, Iridovirus, and TILV analyses 7. Submitted fish samples to BFAR CD NFLD- negative results
	3	10/23/2024	Oriental Mindoro	Bongabong	Labasan	Used of expired commercial feeds and fluctuations in water parameters due to continuous rainwater	Milkfish (juvenile)	509 pcs Milkfish	Php 2,240	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collected fish samples for VNN, and Iridovirus analyses 5. Collected environmental fish samples for VNN, Iridovirus, and TILV analyses
	4	3/28/2025	Oriental Mindoro	Naujan	Barcenaga	Parasitism (Trichodina spp.)	Tilapia (breeders)	6 pcs tilapia	Php 3,600	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collection of live samples (with clinical signs) 5. Conducted parasitology
	5	6/3/2025	Oriental Mindoro	San Teodoro	Calsapa	Suspected pesticide poisoning	Needlefish, Trevally, Barracuda, Goby, Shrimp, Grunter, Mullet, Glassy Perchlet, Northern Whiting	Estimated: More than 7kgs Submitted: 128 pcs fishes equivalent to 1.074 kgs	Php 1,400	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collection of samples (dead fishes) 5. Conducted fish necropsy 6. Advised LGU to submit 2 sets of fish samples (pelagic and demersal), caught as live for pesticide analysis. However, no samples were submitted

Figure 3.D.8. Region IV-B, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Annex 3.E. Solid Waste Pollution Indicators

The solid waste dataset used in the narrative was obtained from the Compendium of Philippine Environment Statistics (CPES) published by the Philippine Statistics Authority (PSA), supplemented with data from an academic journal. The PSA projected annual waste generation was computed using the 2010 Philippine Population Census as the baseline. Meanwhile, the identification of the top plastic-emitting rivers was based on a modelled study conducted by Meijer et al. (2021). Given that this report focuses on regions and provinces contributing to the Philippine Waters of the SCS-LME, data from other regions were aggregated to be concise.

Table 3.E.1. Projected Amount of Solid Waste Generated in the Philippines per Day (2014-2023) (PSA, 2024).

Year	Unit	Philippines	NCR	CAR	Region I	Region II	Region III	Region IV-A	Region IV-B	Other Regions
2014	Mass (tons/day)	50,409	7,933	798	2,350	1,557	5,863	7,854	1,375	22,679
2015	Mass (tons/day)	51,424	8,073	812	2,379	1,579	5,990	8,105	1,401	23,085
2016	Mass (tons/day)	52,463	8,216	827	2,408	1,601	6,120	8,365	1,429	23,497
2017	Mass (tons/day)	53,527	8,363	842	2,438	1,624	6,252	8,634	1,457	23,917
2018	Mass (tons/day)	54,616	8,512	858	2,469	1,646	6,388	8,912	1,486	24,345
2019	Mass (tons/day)	55,731	8,665	873	2,499	1,669	6,526	9,200	1,515	24,784
2020	Mass (tons/day)	56,874	8,821	889	2,531	1,693	6,668	9,498	1,545	25,229
2021	Mass (tons/day)	58,044	8,981	906	2,562	1,716	6,813	9,806	1,576	25,684
2022	Mass (tons/day)	59,243	9,144	922	2,594	1,740	6,962	10,125	1,608	26,148
2023	Mass (tons/day)	60,640	9,290	962	2,584	1,762	7,095	10,455	1,614	26,878

Table 3.E.2. Number of Disposal Facilities in the Philippines from 2012-2023 (PSA, 2024).

Spatial Coverage	Year	Illegal Dump	MRFs	Sanitary Landfill
Philippines	2012	945	7,713	45
Philippines	2013	923	8,486	72
Philippines	2014	900	8,656	86
Philippines	2015	553	9,335	101
Philippines	2016	511	9,883	118
Philippines	2017	385	10,052	135
Philippines	2018	353	10,340	165
Philippines	2019	331	10,722	187
Philippines	2020	233	11,546	241
Philippines	2021	0	11,637	245
Philippines	2022	0	11,779	290
Philippines	2023	43	11,823	299

Table 3.E.3. Top Plastic Emitting Rivers in the Philippines based on the model study of Meijer et al. (2021).

Ranking (from Meijer et al. in 2021)	River	Best Calibrated Scenario (tons/yr)	Drains to the Philippine Waters of SCS-LME?
1	Pasig	63,000	Yes (drains through Manila Bay)
2	Tullahan	13,000	Yes (drains through Manila Bay)
5	Meycauayan	12,000	Yes (drains through Manila Bay)
6	Pampanga	9,300	Yes (drains through Manila Bay)
7	Libmanan	7,100	No
9	Rio Grande de Mindanao	5,300	No
10	Agno	4,600	Yes (drains through Lingayen Gulf)
11	Agusan	4,600	No
12	Paranaque	4,400	Yes (drains through Manila Bay)
13	Iloilo	4,200	No
24	Imus	3,100	Yes (drains through Manila Bay)
29	Zapote	2,700	Yes (drains through Manila Bay)
32	Cagayan de Oro	2,600	No
33	Davao River	2,600	No
38	Malaking Tubig	2,500	No
40	Tambo, Pasay (Storm drain)	2,500	Yes (drains through Manila Bay)
42	Jalaur River	2,300	No
46	Cagayan River	2,300	No
50	Hamulaun	2,200	No



Figure 3.E.1 Plastic Debris found in the coastal waters of Balayan Bay, Mabini, Batangas.

Annex 3.F. Hazardous Waste Pollution Indicators

The dataset for hazardous waste was extracted from the Compendium of Philippine Environment Statistics (CPES), released periodically by the Philippine Statistics Authority. Table 3.F.1 presents the hazardous waste generated, classified by type, while Table 3.F.2 presents the aggregated hazardous waste generated by region per year. Table 3.F.3 shows the amount generated and treated, as well as the cumulative generated and treated waste. The Multi-Year Treatment Rate (MTR) was obtained by getting the ratio of cumulative treatment to the cumulative generated per year. The last column contains the number of TSD Facilities in the Philippines.

Table 3.F.1. Hazardous Waste Generated by Type per Year in tons (2012-2023)

Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	Mean
Waste with Cyanide	112,620.48	565,841.03	190,714.45	401,467.43	191,367.41	1,428,453.17	395,537.25	1,047,561.50	465.6	899.98	977.58	781.46	4,336,687.34	361,390.61
Acid Wastes	281,166.97	100,891.15	271,959.28	317,403.61	10,096.50	39,024.07	2,759.65	15,314.82	1,282.65	4,481.85	3,952.36	4,220.61	1,052,553.52	87,712.79
Alkali Wastes	53,086.00	195,009.36	579,074.32	983,030.13	361,916.41	14,703.85	70,538.76	193,714.02	3,556.62	21,258.78	22,725.57	9,944.8	2,508,558.30	209,046.53
Waste with Inorganic Chemicals	29,081.96	269,815.90	806,358.72	710,107.45	88,511.56	43,219.74	24,349.58	2,896.162	6,309.88	18,781.08	21,555.88	22,443.65	4,936,698.26	411,391.52
Reactive Chemical Wastes	337.11	464,668.17	63.15	330.35	425.82	503.17	367.06	5,041.30	97	245.02	995.34	802.79	473,876.28	39,489.69
Inks, Dyes, Pigments, Paint, Latex, Adhesives,	5,475.11	10,418.35	134,881.37	67,807.14	14,604.04	16,595.62	41,948.78	36,191.36	7,381.62	27,381.62	27,685.19	27,953.24	418,323.44	34,860.29
Organic Sludge Waste	165.13	352,386.98	27,970.13	33,822.49	6,941.93	7,398.92	8,373.92	57,277.32	6,448.80	18,445.97	15,572.87	15,888.76	715,659.32	59,638.28
Organic Solvent Wastes	23,958.78	620,720.09	513.06	5,365.68	1,961.19	3,280.06	2,454.35	32,645.43	930.47	5,343.55	6,899.72	9,586.89	713,659.27	59,471.61
Oil	72,674.83	5,918.533.65	144,694.29	1,351.706.03	744,758.48	220,331.10	75,344.75	302,401.17	20,084.39	65,457.17	71,958.19	76,328.12	9,064,272.17	755,356.01
Containers	13,856.43	432,478.33	13,448.22	15,564.60	5,149.26	17,837.93	15,012.94	28,539.21	1,276.54	5,603.30	6,167.08	5,671.32	560,605.16	46,717.10
Immobilized/Stabilized Wastes	3,401.79	1,486.10	4,846.70	2,377.17	2,797.70	6,164.20	222.024.56	18,843.93	9,609.25	30,645.36	33,720.60	18,430.64	354,348.00	29,529.00
Organic Chemicals	36.86	115.04	2,302.40	928.82	237.85	2,386.55	67,572.90	345.01	39.35	312.27	203.95	619.05	75,100.05	6258.3375
Miscellaneous Wastes	19,689.37	44,597.59	322,161.56	442,311.44	57,039.85	298.646.89	64,971.54	189,122.62	9,683.63	39,316.14	40,344.33	45,586.91	1,573,471.87	131,122.66

Table 3.F.2. Total Hazardous Waste Generated Per Region in tons (2012-2023)

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	% Ctrbn
NCR	14,710.66	606,417.84	187,607.56	218,753.01	114,969.90	47,575.91	38,899.32	33,754.75	11,252.21	23,877.16	29,709.49	38,679.98	1,366,207.79	5.10
CAR	0	0	0	217,809.10	21,304.08	194,739.83	369,559.49	2,403,828.32	672.22	2,437.74	2,641.66	3,264.74	3,216,257.18	12.01
Region 1	4,374.63	0	1,467.93	2,030.48	1,691.13	4,378.35	4,905.67	3,704.25	892.08	2,859.79	2,874.98	2,871.67	32,050.96	0.12
Region 2	279.2	73.82	51.61	0	10.25	109.97	156.3	944.61	58.78	1,265.86	1,670.46	1,819.46	6,440.32	0.02
Region 3	279,848.18	1,809,183.89	0	1,344.076.60	626,366.99	246,407.70	331,613.98	49,065.38	14,288.58	54,032.95	48,166.12	40,994.90	4,844,045.27	18.09
Region 4A	282,846.18	5,943,932.49	273,669.50	976,186.65	118,569.78	278,059.85	106,116.86	1,171.44	31,709.44	117,083.09	127,486.15	111,612.97	9,538,746.08	35.61
Region 4B	0	0	65.17	0	3,211.57	712.65	342.52	480.87	255.5	1,724.59	2,374.41	2,108.76	11,276.04	0.04
Region 5	41,127.70	0	639,622.88	8,637.65	26,656.01	23,197.66	498.43	10,565.65	613.95	2,921.80	2,816.47	3,605.26	760,263.46	2.84
Region 6	0	299,290.69	1,299.29	1,950.38	1,133.76	3,643.43	3,773.78	2,998.08	399.34	2,299.21	3,852.46	2,777.01	32,341.43	1.21

Region 7	0	0	451,877.11	278,022.55	383,674.06	18,069.68	51,016.18	191,328.01	3,017.31	12,718.34	12,432.67	12,096.72	141,425.263	5.28
Region 8	0	0	508.64	10,674.41	20,777.07	24,044.80	10,892.73	129,992.52	42.88	938.15	1,087.50	1,448.91	200,407.61	0.75
Region 9	978.56	8,073.58	688.46	527.33	23,217.20	3,384.50	2,069.54	1,391.26	26.57	242.38	540.07	402.27	41,541.72	0.16
Region 10	0	1,983.11	786,482.29	871,931.94	0	9,603.50	14,309.28	18,989.13	3,227.68	10,764.48	11,147.49	11,014.22	173,945.312	6.49
Region 11	101,179.64	55,171.40	116,589.34	120,472.02	4,476.86	1,230.147.51	16,763.83	648,227.49	381.5	2,625.43	2,993.54	3,002.94	2,302.031.50	8.59
Region 12	0	0	280.88	0	406.71	1,417.46	1,689.30	2,077.42	84.94	878.77	1,093.09	1,132.38	9060.95	0.03
Region 13	55,177.92	252,829.17	38,777.00	281,150.20	139,342.63	13,052.48	38,648.86	154,339.68	242.82	1,872.33	1,872.11	1,425.73	978,730.93	3.65
BARM M	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 3.F.3. Hazardous Waste Generated, Treated, Cumulative, Multi-Year Treatment Rate, and TSD Facilities in the Philippines (2012-2023).

Spatial Coverage	Year	Generated (tons)	Treated (tons)	Cumulative Generated (tons)	Cumulative Treated (tons)	MTR (%)	TSD Facilities (n)
Philippines	2012	780,522.67	444,358.91	780,522.67	444,358.91	56.93	130
Philippines	2013	8,976,955.99	6,638,379.99	9,757,478.66	7,082,738.90	72.59	127
Philippines	2014	2,498,987.65	962,400.78	12,256,466.31	8,045,139.68	65.64	114
Philippines	2015	4,332,222.34	1,579,719.49	16,588,688.65	9,624,859.17	58.02	123
Philippines	2016	1,485,808.00	603,470.61	18,074,496.65	10,228,329.78	56.59	135
Philippines	2017	2,098,545.27	2,363,934.01	20,173,041.92	12,592,263.79	62.42	128
Philippines	2018	991,256.04	510,659.39	21,164,297.96	13,102,923.18	61.91	132
Philippines	2019	4,823,160.55	10,740,340.85	25,987,458.51	23,843,264.03	91.75	131
Philippines	2020	67,165.80	58,569.14	26,054,624.31	23,901,833.17	91.74	127
Philippines	2021	238,172.09	237,412.88	26,292,796.40	24,139,246.05	91.81	162
Philippines	2022	252,758.66	247,010.66	26,545,555.06	24,386,256.71	91.87	153
Philippines	2023	238,257.92	222,706.01	26,783,812.98	24,608,962.72	91.88	175

Annex 3.G. Oil Pollution Indicator

The dataset for oil pollution was compiled from multiple sources, including academic journals, news articles, and government reports. The volume from major oil spill events were aggregated per year from Table 3.G.2 to provide a comprehensive assessment of their contribution to the available total national data and their potential impact on marine ecosystems.

Table 3.G.1. Total Volume of Recorded Oil Spill in the Philippines from 2000-2021 (Agaton et al., 2023; Alea et al., 2022; NDRRMC, 2024; Yuching, 2024).

Spatial Coverage	Year	Volume	No. of Major Oil Spill (>1,000,00 L)	No. of Incidence with Oil Discharge > 10,000 L
Philippines	2000	76,660	0	2
Philippines	2001	45,014	0	1
Philippines	2002	24,800	0	0
Philippines	2003	14,990	0	0
Philippines	2004	28,750	0	0
Philippines	2005	516,500	0	2
Philippines	2006	2,118,500	1	1
Philippines	2007	17,750	0	0
Philippines	2008	24,100	0	0
Philippines	2009	1,000	0	0
Philippines	2010	11,400	0	0
Philippines	2011	4,710	0	0
Philippines	2012	56,595	0	3
Philippines	2013	1,496,600	0	4
Philippines	2014	15,600	0	0
Philippines	2015	5,000	0	0
Philippines	2016	15,600	0	0
Philippines	2017	22,736	0	0
Philippines	2018	78,615	0	0
Philippines	2019	7,676	0	0
Philippines	2020	269,904	0	1
Philippines	2021	8,787	0	0
Philippines	2022*	269,000	0	1
Philippines	2023*	850,000	0	1
Philippines	2024*	1,450,000	1	1

* Single Oil Spill Event Only as Reported

Table 3.G.2. Assessment of oil pollution contribution to the national data and their potential impact on marine ecosystems (Agaton et al., 2023; Alea et al., 2022; NDRRMC, 2024; Yuching, 2024).

Date	Locality	Region	Volume (liters)	Cause	Relevance to Philippine Waters of SCS-LME
Jan 27, 2000	Lingayen Gulf	I	57,000	The bulk carrier M/V Nol Scheddar ran aground.	Important: Located in Lingayen Gulf facing Philippine Waters of SCS-LME.
Jun 29, 2000	Ilana Bay	ARMM	18,000	A hose that pumps diesel from a tanker to a Caltex depot was sliced by an unidentified assailant.	Not directly relevant
Jul 17, 2001	Davao Gulf	XI	12,500	Singapore-owned container vessel Pacific Eagle collided with M/V Dingalan Bay causing it to sink.	Not directly relevant

Mar 06, 2005	Davao Gulf	XI	128,000	The oil tank of M/V Cala Piccola cracked.	Not directly relevant
Dec 18, 2005	Semirara Island	VI	364,000	NPC Power Barge 106 ran aground that ruptured its tanks.	Not directly relevant
Aug 11, 2006	Guimaras Strait	VI	2,100,000	Oil tanker M/T Solar 1 sank. This was considered the worst oil spill in Philippine history at that time.	Not directly relevant
Feb 21, 2012	La Union	I	10,000	Leaked in the pipeline while M/T Panglao Island was transferring diesel fuel to a Chevron Bulk Plant.	Important: Located in La Union facing Philippine Waters of SCS-LME
Apr 03, 2012	Polilo Island	IV-A	10,000	Leaked in the generator of the NPC's power source.	Not directly relevant
Feb 07, 2012	Mactan Channel	VII	10,000	M/V B & E Uno sank.	Not directly relevant
Feb 17, 2013	Bolinao	I	10,000	M/V Harita Bauxite encountered engine troubles causing it to sink.	Important: Located in Pangasinan facing Philippine Waters of SCS-LME
Aug 08, 2013	Manila Bay, Cavite	IV-A	500,000	Leaked in the submerged pipeline of Petron Corporation.	Important: Manila Bay connects to Philippine Waters of SCS-LME
Aug 16, 2013	Mactan Channel	VII	160,000	Domestic passenger ferry M/V St. Thomas Aquinas collided with M/V Sulpicio Express Siete causing it to sink.	Not directly relevant
Nov 09, 2013	Estancia, Iloilo	VI	800,000	NPC Power Barge 103 dislodged from its mount caused by Super Typhoon Haiyan.	Not directly relevant
Jul 03, 2020	Iloilo Strait	VI	268,949	AC Energy Power Barge 102 exploded.	Not directly relevant
Feb 28, 2023	Off Naujan, Oriental Mindoro	MIMAROPA	800,000-900,000	MT Princess Empress, en route from Bataan to Iloilo, sank after encountering rough seas. The oil spread to parts of Oriental Mindoro, Batangas, Palawan, and Antique.	Important: Affected parts of Palawan which faces Philippine Waters of SCS-LME
Jul 25, 2024	Limay, Bataan (Manila Bay)	III	1,400,000-1,500,000	MT Terra Nova capsized and sank due to rough seas during Typhoon Gaemi. Oil spill spread to multiple provinces along Manila Bay.	Important: Manila Bay connects to Philippine Waters of SCS-LME

Annex 3.H. Atmospheric Deposition Pollution Indicators

The dataset was extracted from the EANET database to compile the complete Philippine wet-deposition and dry concentration time-series (2000 – 2023) for sulfate-S and nitrate-N for all three EANET sites into a single tidy worksheet. Site code: PHA001 (Manila), PHA002 (Los Banos), and PHA003 (Mt. Sto Tomas)

This report summarizes 4-year block averages (2000–2003 ... 2020–2023) of wet deposition (SO₄-S, NO₃-N) and dry concentrations (pSO₄, pNO₃) at PHA001–PHA003, with overlays of site series against the aggregate (mean across sites). Missing data may imply issues with monitoring equipment.

The Annex includes Tables of summarized data with descriptive statistics: number of valid years (n), completeness (n/4), mean, standard error (SE), standard deviation (SD), median, minimum, and maximum for each site × indicator × block.

Table 3.H.1. Raw Data for Wet Deposition (SO₄-S, NO₃-N, mmol/m²y) (Network Center for EANET, 2025).

Indicator	Year	Monitoring Stations		
		Manila Observatory	Los Banos	Mt. Sto Tomas
NO3-N	2000	49	14	
NO3-N	2001	42	25	
NO3-N	2002	52	14	
NO3-N	2003	29	8	
NO3-N	2004	33	11	
NO3-N	2005	51	16	
NO3-N	2006	33	18	1
NO3-N	2007	49	19	18
NO3-N	2008	50	15	20
NO3-N	2009	33	23	19
NO3-N	2010	135	65	15
NO3-N	2011	53	20	12
NO3-N	2012	81.37	25.01	35
NO3-N	2013	49	19	37
NO3-N	2014	42	17	18
NO3-N	2015	33	14	21
NO3-N	2016	91.8	67.7	25.5
NO3-N	2017			
NO3-N	2018			
NO3-N	2019	31		
NO3-N	2020	28		
NO3-N	2021	34		
NO3-N	2022	50	20	2
NO3-N	2023	49	17	
SO4-S	2000	94	28	
SO4-S	2001	86	28	
SO4-S	2002	78	27	
SO4-S	2003	38	11	
SO4-S	2004	44	15	

SO4-S	2005	57	16	
SO4-S	2006	47	24	1
SO4-S	2007	78	26	19
SO4-S	2008	59	34	18
SO4-S	2009	51	26	24
SO4-S	2010	54	15	18
SO4-S	2011	68	20	22
SO4-S	2012	107.6	26.53	42
SO4-S	2013	53	16	34
SO4-S	2014	47	19	17
SO4-S	2015	47	21	25
SO4-S	2016	54.7	27	24.4
SO4-S	2017			
SO4-S	2018			
SO4-S	2019	24		
SO4-S	2020	29		
SO4-S	2021	46		
SO4-S	2022	45	33	2
SO4-S	2023	51	39	

Table 3.H.2. Raw Data for Dry Deposition (pSO₄, pNO₃, mg/L) (Network Center for EANET, 2025).

Indicator	Year	Monitoring Stations		
		Manila Observatory	Los Banos	Mt. Sto Tomas
pNO3	2000	0.074406	0.031002	
pNO3	2001	0.117809	0.086807	
pNO3	2002	0.111609	0.049604	
pNO3	2003	0.080606	0.031002	
pNO3	2004	0.093007	0.037203	
pNO3	2005	0.136411	0.062005	
pNO3	2006	0.074406	0.049604	0.012401
pNO3	2007	0.086807	0.037203	0.031002
pNO3	2008	0.13021	0.049604	0.024802
pNO3	2009	0.055804	0.049604	0.024802
pNO3	2010	0.310025	0.192215	0.024802
pNO3	2011	0.086807	0.049604	0.018601
pNO3	2012	0.112849	0.074406	0.037203
pNO3	2013	0.086807	0.049604	0.049604
pNO3	2014	0.099208	0.049604	0.031002
pNO3	2015	0.080606	0.055804	0.018601
pNO3	2016	0.225698	0.238719	0.035963
pNO3	2017			
pNO3	2018			
pNO3	2019	0.080606		
pNO3	2020	0.068205		

pNO3	2021	0.080606		
pNO3	2022	0.111609	0.055804	0.024802
pNO3	2023	0.086807	0.049604	
pSO4	2000	0.220938	0.105666	
pSO4	2001	0.355422	0.153696	
pSO4	2002	0.249756	0.153696	
pSO4	2003	0.163302	0.067242	
pSO4	2004	0.19212	0.076848	
pSO4	2005	0.230544	0.09606	
pSO4	2006	0.172908	0.105666	0.009606
pSO4	2007	0.211332	0.076848	0.057636
pSO4	2008	0.24015	0.172908	0.028818
pSO4	2009	0.134484	0.086454	0.04803
pSO4	2010	0.19212	0.067242	0.04803
pSO4	2011	0.182514	0.086454	0.04803
pSO4	2012	0.231505	0.124878	0.067242
pSO4	2013	0.14409	0.067242	0.076848
pSO4	2014	0.172908	0.086454	0.04803
pSO4	2015	0.182514	0.124878	0.038424
pSO4	2016	0.20845	0.147932	0.052833
pSO4	2017			
pSO4	2018			
pSO4	2019	0.09606		
pSO4	2020	0.105666		
pSO4	2021	0.172908		
pSO4	2022	0.153696	0.14409	0.038424
pSO4	2023	0.134484	0.172908	

Table 3.H.3. Aggregated across sites — Wet deposition (SO4-S, NO3-N): stats per 4-yr block

Phase	Indicator	Block	n_sites	mean	se	std	median	min	max
wet	NO3-N	2000-2003	2	24.958	13.872	19.618	24.958	11.086	38.83
wet	NO3-N	2004-2007	3	26.165	9.284	16.08	18.467	15.381	44.647
wet	NO3-N	2008-2011	3	42.777	18.959	32.837	33.286	15.731	79.315
wet	NO3-N	2012-2015	3	35.972	11.124	19.268	30.207	20.244	57.464
wet	NO3-N	2016-2019	1	31.007			31.007	31.007	31.007
wet	NO3-N	2020-2023	3	20.392	11.035	19.114	18.492	2.3	40.385
wet	SO4-S	2000-2003	2	42.788	23.223	32.843	42.788	19.565	66.011
wet	SO4-S	2004-2007	3	32.699	13.516	23.411	19.403	18.963	59.73
wet	SO4-S	2008-2011	3	34.302	13.197	22.857	23.299	19.027	60.58
wet	SO4-S	2012-2015	3	40.163	14.878	25.77	30.76	20.415	69.314
wet	SO4-S	2016-2019	1	24.118			24.118	24.118	24.118
wet	SO4-S	2020-2023	3	27.079	12.515	21.676	36.003	2.365	42.868

Table 3.H.4. Aggregated across sites — Dry concentrations (pSO4, pNO3): stats per 4-yr block

Phase	Indicator	Block	n_sites	mean	se	std	median	min	max
dry	pNO3	2000-2003	2	0.955	0.285	0.403	0.955	0.67	1.24
dry	pNO3	2008-2011	2	0.65	0.2	0.283	0.65	0.45	0.85

dry	pNO3	2012-2015	1	0.215			0.215	0.215	0.215
dry	pNO3	2016-2019	2	0.745	0.605	0.856	0.745	0.14	1.35
dry	pNO3	2020-2023	2	1.596	0.069	0.097	1.596	1.527	1.665
dry	pSO4	2000-2003	2	2.105	0.575	0.813	2.105	1.53	2.68
dry	pSO4	2008-2011	2	1.105	0.325	0.46	1.105	0.78	1.43
dry	pSO4	2012-2015	1	0.242			0.242	0.242	0.242
dry	pSO4	2016-2019	2	1.315	1.015	1.435	1.315	0.3	2.33
dry	pSO4	2020-2023	2	3.642	0.307	0.435	3.642	3.335	3.95

Annex 3.I. Methodology for Computing Risk Quotients (RQs) for Pollution Indicators

1. Purpose and Scope

This document provides guidance for using the Risk Quotient (RQ) method to assess water quality. While environmental agencies primarily use standard water quality indices to assess parameters such as dissolved oxygen, nutrients, total suspended solids (TSS), and biochemical oxygen demand (BOD), the RQ method offers an approach for assessing ecological risks associated with specific pollutants. This document thus provides a step-by-step, ready-to-implement procedure to estimate the Risk Quotients (RQs) for the aquatic ecosystem associated with the pollution indicators identified as critical for the Philippines' waters in the South China Sea LME. The approach follows the standard environmental risk paradigm where $RQ = (PEC \text{ or } MEC) \div \text{Threshold (PNEC or guideline)}$. See Annex 3.A for raw data on concentrations used for computing the RQs.

2. Key Definitions

- PEC: Predicted Environmental Concentration at the site
- MEC: Measured Environmental Concentration at the site
- PNEC/Threshold: environmental concentration protective of aquatic life or a relevant guideline/criterion.
- RQ (Risk Quotient): $(PEC \text{ or } MEC) \div PNEC$. $RQ > 1$ indicates potential risk that may require management decision to take action.
- Risk Band Thresholds: Typically, $RQ \leq 1$ is acceptable (no risk indicated) and $RQ > 1$ is a potential risk (ECHA, 2008), for management prioritization in this project, the following risk bands are used:

Table 3.I.1. Risk Quotient

Risk Band	RQ Threshold	Interpretation
Green	≤ 0.5	Low concern
Yellow	$> 0.5 - 1$	Watch / near threshold
Orange	$> 1 - 3$	Moderate to high; investigate sources
Red	$> 3 - 10$	High to very high; action most likely
Dark Red	> 10	Very high; immediate action

3. Step-by-step Procedure

1. Select indicator(s) from the compiled pollution indicators database (e.g., nitrate, ammonia, phosphate, dissolved oxygen, total suspended solids, fecal coliform, and plastic pollution—see Annex 3.1).
2. Compile site measurements or reported data as MEC values. PEC values are estimated from the sample statistics. For a reasonable worst-case scenario, the 95th percentile of the computed risk quotients is used for the computation. Handle non-detects using half the detection limit unless the project policy specifies otherwise
3. Choose the most conservative threshold source for PNEC from the following sources: (a) Philippine marine WQG for the water class (DENR, 2016; updated items per DENR, 2021); (b) ASEAN AMWQC for aquatic-life protection (ASEAN Secretariat, 2008); (c) peer-reviewed PNEC from authoritative frameworks (ECHA, 2008; US EPA, 1985).
4. Ensure unit consistency (e.g., convert ASEAN nutrient criteria in $\mu\text{g/L}$ to mg/L or vice versa).
5. Compute $RQ = (PEC \text{ or } MEC) \div \text{Threshold}$ for each record. Note that for Dissolved Oxygen as an indicator, the inverse is used to compute the RQ.
6. Assign management bands (see Table 3.I.1). ECHA (2008) considers $RQ \leq 1$ acceptable; project bands further prioritize actions.
7. Aggregate and map results (e.g., by site category). Flag any indicators with $RQ > 1$ or repeated exceedances.

8. Estimate the 95th percentile RQ in each indicator for different sites as the reasonable worst-case (rwc) scenario.
9. Document assumptions, detection limits, and any conversions performed.

4. Worked example

Example: PEC for nitrate (as NO₃-N) = 0.80 mg/L at a Class SB site. Threshold choices:

- PH WQG (SB): 10 mg/L → RQ = 0.80 / 10 = 0.08 (Green). (DENR, 2016)
- ASEAN AMWQC: 60 µg/L = 0.060 mg/L → RQ = 0.80 / 0.060 ≈ 13.3 (Red). (ASEAN Secretariat, 2008)
- For a conservative risk estimate, such as for a reasonable worst-case scenario, use ASEAN AMWC. The national ambient WQG indicates compliance, but the ASEAN ecological criterion signals a sensitivity concern; both could be reported transparently depending on the management context.

5. Summary of Results

The risk quotient (RQ) analysis provides a quantitative basis for evaluating pollution risks across sites and indicators. Using site-specific measured concentrations, we derived central tendencies and extreme values, and then translated these into risk quotients relative to predicted no-effect concentrations (PNECs).

For most indicators, the reasonable worst-case (RWC) condition was represented by the 95th percentile RQ (RQ_{p95}). These statistics allow us to distinguish typical risk levels (median RQ) from worst-case scenarios.

The traffic-light classification highlights distinct spatial and indicator-specific patterns:

- Red and Dark Red bands dominate in Manila Bay and Lingayen Gulf, especially for fecal coliforms, nutrients (nitrate, phosphate), and TSS, indicating frequent exceedances of ecological thresholds.
- Batangas Bay and VIP show elevated risks for BOD, heavy metals (lead, cadmium), and oil-related parameters, reflecting industrial activity.
- Palawan West Coast generally falls in the Green–Yellow bands, except for localized hotspots (microbial contamination in Bacuit Bay).
- Rivers (PW) exhibit extreme values in microbial and nutrient indicators, with RQ_{p95} exceeding Dark Red thresholds, signifying high pollution loading from upstream catchments.

Overall, the RQ analysis confirms that nutrient enrichment, organic pollution, and microbial contamination remain the highest risk concerns in Philippine coastal waters, with emerging risks from microplastics and metals. The traffic-light pivots offer a transparent, visual tool for prioritizing management interventions and aligning them with hotspot-specific conditions.

Table 3.I.2. PNEC Values based on DENR and ASEAN Water Quality Standard (DENR Administrative Order 2016-08, DENR Administrative Order 2021-19*, DENR Administrative Order No. 34 s. 1990**, ASEAN Marine Water Quality Management Guidelines and Monitoring).

PARAMETER	Unit	PNEC VALUES FOR WATER QUALITY									
		ASEAN Marine WQC	DENR (Marine Water)				DENR (Freshwater)				
			SA	SB	SC	SD	AA	A	B	C	D
Nitrate	mg/L	0.06	10	10	10	15	7	7	7	7	15
Nitrite	mg/L	0.055	-	-	-	-	-	-	-	-	-
Ammonia	mg/L	0.07	0.04*	0.06*	0.06*	0.3*	0.06*	0.06*	0.06*	0.06*	0.3*
Phosphate	mg/L	0.015/0.045 (coastal/estuarine)	0.1*	0.2*	0.2*	0.4*	0.025*	0.025*	0.025*	0.025*	0.05*
BOD	mg/L	-	3**	5**	7**	-	1	3	5	7	15
DO (minimum)	mg/L	4	6	6	5	2	5	5	5	5	2
Fecal Coliform	MPN/100mL	100	20*	100*	200*	400*	20*	50*	100*	200*	400*
Total Coliform**	MPN/100mL	-	70	1000	5000	-	50	1000	1000	5000	-
TSS	mg/L	Permissible 10% maximum increase over seasonal average concentration.	25	50	80	110	25	50	65	80	110
Oil and grease	mg/L	0.14	1	2	3	5	<1	1	1	2	5
Arsenic	mg/L		0.01	0.01	0.02	0.04	0.01	0.01	0.01	0.02	0.04
Cadmium	mg/L	0.01	0.003	0.003	0.005	0.01	0.003	0.003	0.003	0.005	0.01
Chromium (VI)	mg/L	0.05	0.05	0.05	0.05	0.1	0.01	0.01	0.01	0.01	0.02
Copper	mg/L	0.008	0.2*	0.2*	0.2*	0.4*	0.2*	0.2*	0.2*	0.2*	0.4*
Iron	mg/L		1.5	1.5	1.5	7.5	1	1	1	1.5	7.5
Lead	mg/L	0.0085	0.01	0.01	0.05	0.1	0.01	0.01	0.01	0.05	0.1
Zinc	mg/L		0.04	0.05	0.8	1.5	2	2	2	2	4
Mercury	mg/L	0.00016	0.001	0.001	0.002	0.004	0.001	0.001	0.001	0.002	0.004

Table 3.I.3. PNEC Values for General Effluent Standard on Fecal Coliform based on DENR Administrative Order 2021-19 NDA – No Discharge Allowed

Parameter	Unit	DENR (Marine Water)				DENR (Freshwater)				
		SA	SB	SC	SD	AA	A	B	C	D
Fecal Coliform	MPN/100mL	NDA	200	400	800	NDA	100	200	400	800

Table 3.I.4. PNEC Value for Microplastics in Waterbodies based from Mehinto et al. (2022)

Parameter	Unit	Threshold
Microplastics	particles/m ³	300

Summary Tables and Heat Map for Risk Quotients (RQ)

This section provides the summary table for computations of RQ as mentioned above, and obtaining the median, minimum, maximum, 95th percentile of the RQs. The 95th percentile is considered the reasonable worst-case scenario (rwc).

Table 3.I.5. Computed RQs based on DENR Water Quality Standards for Pollution Hotspots.

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP (Hotspots)	BOD	mg/L	5	0.9	0.69	1.3	1.3	1.3
Batangas Bay and VIP (Hotspots)	DO	mg/L	13	0.83	0.62	0.96	0.95	0.95
Batangas Bay and VIP (Hotspots)	Fecal Coliform	MPN/100mL	3	15	7.5	20	20	20
Batangas Bay and VIP (Hotspots)	Total Coliform	MPN/100mL	7	0.7	0.021	17	14	14
Batangas Bay and VIP (Hotspots)	Cadmium	mg/L	1	25	25	25	25	25
Batangas Bay and VIP (Hotspots)	Chromium	mg/L	1	1.3	1.3	1.3	1.3	1.3
Batangas Bay and VIP (Hotspots)	Lead	mg/L	7	32	2.5	37	37	37
Batangas Bay and VIP (Hotspots)	Nitrate	mg/L	8	0.0015	0	0.029	0.02	0.02
Batangas Bay and VIP (Hotspots)	Phosphate	mg/L	2	1.3	0	2.7	2.5	2.5
Batangas Bay and VIP (Hotspots)	TSS	mg/L	9	0.2	0.013	0.44	0.44	0.44
Lingayen Gulf (Hotspot)	DO	mg/L	4	1.8	0.59	2.4	2.4	2.4
Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100mL	2	40	0.1	80	76	76
Lingayen Gulf (Hotspot)	Nitrate	mg/L	7	0.023	0	0.091	0.077	0.077
Lingayen Gulf (Hotspot)	Phosphate	mg/L	12	0.25	0	1.5	1.3	1.3
Lingayen Gulf (Hotspot)	TSS	mg/L	2	4.1	0.0063	8.1	7.7	7.7
Manila Bay (Hotspot)	BOD	mg/L	6	0.72	0.56	1.2	1.2	1.2
Manila Bay (Hotspot)	DO	mg/L	54	1.2	0.76	2.6	2.3	2.3
Manila Bay (Hotspot)	Fecal Coliform	MPN/100mL	36	1.6	0.01	600	110	110
Manila Bay (Hotspot)	Total Coliform	MPN/100mL	15	4	0.22	26	17	17
Manila Bay (Hotspot)	Cadmium	mg/L	16	700	0.067	19000	17000	17000
Manila Bay (Hotspot)	Chromium	mg/L	10	5.6	0.2	18	13	13
Manila Bay (Hotspot)	Lead	mg/L	16	30	0.78	74	71	71
Manila Bay (Hotspot)	Mercury	mg/L	6	0.7	0.4	2.2	1.9	1.9
Manila Bay (Hotspot)	Nitrate	mg/L	34	0.017	0.0016	0.25	0.22	0.22
Manila Bay (Hotspot)	Phosphate	mg/L	34	0.92	0.054	4.4	3.6	3.6
Manila Bay (Hotspot)	TSS	mg/L	25	0.74	0.12	3.6	3	3
Manila Bay (Hotspot)	microplastics	pc/m3	4	0.3	0.25	84	71	71
Other Sites	DO	mg/L	5	1.4	1	1.8	1.8	1.8
Other Sites	Fecal Coliform	MPN/100mL	6	1.8	0.36	7.8	7	7
Other Sites	Total Coliform	MPN/100mL	3	0.077	0.018	0.1	0.099	0.099
Palawan West Coast	DO	mg/L	44	0.88	0.66	1.6	1.1	1.1
Palawan West Coast	Fecal Coliform	MPN/100mL	81	0.17	0.0045	4600	540	540
Palawan West Coast	Total Coliform	MPN/100mL	4	1.1	0.59	54	46	46
Palawan West Coast	Phosphate	mg/L	20	0.095	0.05	0.15	0.13	0.13
Palawan West Coast	TSS	mg/L	20	0.42	0.25	1.8	1.7	1.7

Note: RQ_median - median of RQ values

RQ_min – minimum from the RQ values

RQ_max – maximum from the RQ values

RQ_p95 – 95th percentile of the computed values

RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.I.6. Computed RQs based on ASEAN Water Quality Standards for Pollution Hotspots.

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP (Hotspots)	DO	mg/L	13	0.6	0.41	0.67	0.65	0.65
Batangas Bay and VIP (Hotspots)	Fecal Coliform	MPN/100mL	3	15	7.5	20	20	20
Batangas Bay and VIP (Hotspots)	Cadmium	mg/L	1	12	12	12	12	12
Batangas Bay and VIP (Hotspots)	Chromium	mg/L	1	1.3	1.3	1.3	1.3	1.3
Batangas Bay and VIP (Hotspots)	Lead	mg/L	7	40	15	44	43	43
Batangas Bay and VIP (Hotspots)	Nitrate	mg/L	8	0.25	0	4.8	3.4	3.4
Batangas Bay and VIP (Hotspots)	Phosphate	mg/L	2	1.8	0	3.6	3.4	3.4
Lingayen Gulf (Hotspot)	DO	mg/L	4	1.5	0.47	1.9	1.9	1.9
Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100mL	2	80	0.2	160	150	150
Lingayen Gulf (Hotspot)	Nitrate	mg/L	7	3.9	0	15	13	13
Lingayen Gulf (Hotspot)	Phosphate	mg/L	12	0.34	0	2	1.7	1.7
Manila Bay (Hotspot)	DO	mg/L	54	0.77	0.51	1.7	1.5	1.5
Manila Bay (Hotspot)	Fecal Coliform	MPN/100mL	36	1.6	0.01	600	110	110
Manila Bay (Hotspot)	Cadmium	mg/L	16	210	0.02	5700	5000	5000
Manila Bay (Hotspot)	Chromium	mg/L	10	5.6	0.2	18	13	13
Manila Bay (Hotspot)	Lead	mg/L	16	36	0.92	87	84	84
Manila Bay (Hotspot)	Mercury	mg/L	6	4.4	2.5	14	12	12
Manila Bay (Hotspot)	Nitrate	mg/L	34	2.8	0.27	41	36	36
Manila Bay (Hotspot)	Phosphate	mg/L	34	1.2	0.072	5.8	4.8	4.8
Manila Bay (Hotspot)	microplastics	pc/m3	4	0.3	0.25	84	71	71
Other Sites	DO	mg/L	5	0.95	0.69	1.2	1.2	1.2
Other Sites	Fecal Coliform	MPN/100mL	6	1.8	0.36	7.8	7	7
Palawan West Coast	DO	mg/L	44	0.59	0.44	1.1	0.74	0.74
Palawan West Coast	Fecal Coliform	MPN/100mL	81	0.07	0.009	31	14	14
Palawan West Coast	Phosphate	mg/L	20	0.13	0.067	0.2	0.18	0.18

Note: RQ_median - median of RQ values

RQ_min – minimum from the RQ values

RQ_max – maximum from the RQ values

RQ_p95 – 95th percentile of the computed values

RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.I.7. Computed RQs based on DENR Water Quality Standards for Selected Rivers in the Philippines

Site Category	Indicator	Unit	count	RQ_med.	RQ_min	RQ_max	RQ_p95	RQ_rwc	Drains to PH Waters of SCS-LME
Abra River	BOD	mg/L	3	0.25	0.2	0.27	0.27	0.27	Yes
Abra River	DO	mg/L	8	0.57	0.39	0.68	0.67	0.67	Yes
Abra River	Fecal Coliform	MPN/100mL	2	180	41	310	300	300	Yes
Abra River	Nitrate	mg/L	3	2.4	0.0057	8.3	7.7	7.7	Yes
Abra River	Phosphate	mg/L	3	2	1.2	2.4	2.4	2.4	Yes
Abra River	TSS	mg/L	3	0.84	0.07	2.2	2.1	2.1	Yes

Agno River	BOD	mg/L	13	0.26	0.2	1.4	1.3	1.3	Yes
Agno River	DO	mg/L	19	0.54	0.35	0.87	0.75	0.75	Yes
Agno River	Fecal Coliform	MPN/100mL	3	120	5.4	180	180	180	Yes
Agno River	Nitrate	mg/L	2	1.7	0.031	3.4	3.2	3.2	Yes
Agno River	Phosphate	mg/L	3	2.8	1.6	3.6	3.5	3.5	Yes
Agno River	TSS	mg/L	3	0.6	0.066	1.4	1.3	1.3	Yes
Amburayan River	BOD	mg/L	15	0.22	0.14	0.83	0.78	0.78	Yes
Amburayan River	DO	mg/L	20	0.55	0.37	0.7	0.68	0.68	Yes
Amburayan River	Fecal Coliform	MPN/100mL	3	990	120	1200	1200	1200	Yes
Amburayan River	Nitrate	mg/L	3	0.59	0.11	2.1	1.9	1.9	Yes
Amburayan River	Phosphate	mg/L	3	1.6	1.2	2	2	2	Yes
Amburayan River	TSS	mg/L	3	0.2	0.17	0.29	0.28	0.28	Yes
Angat River	BOD	mg/L	11	1.3	0.37	2.2	1.8	1.8	Yes
Angat River	DO	mg/L	14	1.1	0.7	1.4	1.3	1.3	Yes
Angat River	Fecal Coliform	MPN/100mL	3	150	1	190	190	190	Yes
Angat River	Nitrate	mg/L	3	0.099	0.037	0.15	0.14	0.14	Yes
Angat River	Phosphate	mg/L	3	6.4	5.2	8.8	8.6	8.6	Yes
Angat River	TSS	mg/L	3	0.2	0.19	0.46	0.44	0.44	Yes
Asin Gallano River	BOD	mg/L	17	0.22	0.18	0.69	0.5	0.5	Yes
Asin Gallano River	DO	mg/L	20	0.55	0.25	0.76	0.73	0.73	Yes
Asin Gallano River	Fecal Coliform	MPN/100mL	3	460	99	600	590	590	Yes
Asin Gallano River	Nitrate	mg/L	3	1	0.014	1.6	1.5	1.5	Yes
Asin Gallano River	Phosphate	mg/L	3	4.8	2.8	6	5.9	5.9	Yes
Asin Gallano River	TSS	mg/L	3	0.35	0.19	1.1	1.1	1.1	Yes
Atlag River	BOD	mg/L	5	3.1	2.3	3.7	3.5	3.5	Yes
Atlag River	DO	mg/L	2	2.4	2.2	2.7	2.7	2.7	Yes
Atlag River	Fecal Coliform	MPN/100mL	2	1900	1500	2300	2300	2300	Yes
Atlag River	Nitrate	mg/L	2	0.034	0.031	0.037	0.037	0.037	Yes
Atlag River	Phosphate	mg/L	2	24	18	30	30	30	Yes
Atlag River	TSS	mg/L	2	0.4	0.28	0.53	0.52	0.52	Yes
Balili River	BOD	mg/L	15	7.5	1.4	14	13	13	Yes
Balili River	DO	mg/L	20	0.9	0.51	1.6	1.1	1.1	Yes
Balili River	Fecal Coliform	MPN/100mL	3	4200000	2000000	3800000	3500000	3500000	Yes
Balili River	Nitrate	mg/L	2	0.097	0.097	0.097	0.097	0.097	Yes
Balili River	Phosphate	mg/L	3	48	27	69	67	67	Yes
Balili River	TSS	mg/L	3	0.3	0.28	1.2	1.1	1.1	Yes
Bocae River	BOD	mg/L	21	1.7	0.36	5.6	5.2	5.2	Yes
Bocae River	DO	mg/L	23	1.9	0.63	4.5	3.3	3.3	Yes
Bocae River	Fecal Coliform	MPN/100mL	3	3200	900	3700	3700	3700	Yes
Bocae River	Nitrate	mg/L	2	0.12	0.1	0.13	0.13	0.13	Yes
Bocae River	Phosphate	mg/L	3	110	49	120	120	120	Yes
Bocae River	TSS	mg/L	3	0.47	0.3	0.49	0.49	0.49	Yes
Bued River	BOD	mg/L	18	0.44	0	3.1	2.6	2.6	Yes
Bued River	DO	mg/L	23	0.59	0.45	100	0.78	0.78	Yes

Bued River	Fecal Coliform	MPN/100mL	2	13000	13000	13000	13000	13000	Yes
Bued River	Nitrate	mg/L	1	1.1	1.1	1.1	1.1	1.1	Yes
Bued River	Phosphate	mg/L	2	21	17	25	25	25	Yes
Bued River	TSS	mg/L	3	2	1.8	2.1	2.1	2.1	Yes
Cagayan River	BOD	mg/L	15	0.29	0.14	1.1	0.6	0.6	No
Cagayan River	DO	mg/L	21	0.69	0.53	0.83	0.78	0.78	No
Cagayan River	Fecal Coliform	MPN/100mL	3	19	11	25	25	25	No
Cagayan River	Nitrate	mg/L	3	0.033	0.013	0.033	0.033	0.033	No
Cagayan River	Phosphate	mg/L	3	3.2	3.2	3.6	3.6	3.6	No
Cagayan River	TSS	mg/L	3	0.86	0.61	1.1	1.1	1.1	No
Calao-Delinquente River System	BOD	mg/L	2	0.38	0.38	0.38	0.38	0.38	No
Calapan River	BOD	mg/L	17	1.3	0.55	2.4	2.2	2.2	No
Calapan River	DO	mg/L	19	1.9	1.2	5.6	4.3	4.3	No
Calapan River	Fecal Coliform	MPN/100mL	3	440	210	520	510	510	No
Calapan River	Nitrate	mg/L	2	0.16	0.064	0.25	0.24	0.24	No
Calapan River	Phosphate	mg/L	3	18	10	20	19	19	No
Calapan River	TSS	mg/L	3	0.2	0.18	0.2	0.2	0.2	No
Calumpang River	BOD	mg/L	6	2	0.61	8	6.8	6.8	Yes
Calumpang River	DO	mg/L	3	0.98	0.95	2.3	2.1	2.1	Yes
Calumpang River	Fecal Coliform	MPN/100mL	3	76	49	180	170	170	Yes
Calumpang River	Nitrate	mg/L	3	0.14	0.1	0.29	0.27	0.27	Yes
Calumpang River	Phosphate	mg/L	3	59	38	98	94	94	Yes
Calumpang River	TSS	mg/L	3	0.42	0.28	0.43	0.43	0.43	Yes
Canas River	BOD	mg/L	11	0.66	0.42	1.1	1.1	1.1	Yes
Canas River	DO	mg/L	12	0.83	0.71	0.94	0.93	0.93	Yes
Canas River	Fecal Coliform	MPN/100mL	3	910	700	1000	1000	1000	Yes
Canas River	Nitrate	mg/L	3	0.17	0.16	0.29	0.28	0.28	Yes
Canas River	Phosphate	mg/L	3	44	28	50	50	50	Yes
Canas River	TSS	mg/L	3	0.81	0.66	1	0.99	0.99	Yes
Canas River	microplastics	pc/m3	3	26	5.3	960	870	870	Yes
Dagupan River	BOD	mg/L	7	0.86	0.47	1.2	1.2	1.2	Yes
Dagupan River	DO	mg/L	10	1.2	1	1.4	1.4	1.4	Yes
Diadi River System	BOD	mg/L	2	0.3	0.21	0.38	0.37	0.37	No
Guagua River	BOD	mg/L	10	3.5	0.23	7.3	6.1	6.1	Yes
Guagua River	DO	mg/L	11	1.6	0.88	5	4	4	Yes
Guagua River	Fecal Coliform	MPN/100mL	3	4800	1500	5100	5000	5000	Yes
Guagua River	Nitrate	mg/L	3	0.029	0.024	0.056	0.053	0.053	Yes
Guagua River	Phosphate	mg/L	3	48	48	64	62	62	Yes
Guagua River	TSS	mg/L	3	0.46	0.31	0.47	0.47	0.47	Yes
Hagonoy River	BOD	mg/L	5	1.8	1.1	4	3.7	3.7	Yes
Hagonoy River	DO	mg/L	3	1.5	1.3	2.3	2.2	2.2	Yes
Hagonoy River	Fecal Coliform	MPN/100mL	3	540	380	960	910	910	Yes
Hagonoy River	Nitrate	mg/L	3	0.063	0.054	0.077	0.076	0.076	Yes
Hagonoy River	Phosphate	mg/L	3	12	9.2	12	12	12	Yes

Hagonoy River	TSS	mg/L	3	0.53	0.52	0.62	0.61	0.61	Yes
Imus River	BOD	mg/L	17	1.5	0.81	2.7	2.3	2.3	Yes
Imus River	DO	mg/L	17	0.97	0.37	1.7	1.3	1.3	Yes
Imus River	Fecal Coliform	MPN/100mL	3	2300	890	4000	3800	3800	Yes
Imus River	Nitrate	mg/L	3	0.17	0.17	0.25	0.25	0.25	Yes
Imus River	Phosphate	mg/L	3	62	59	64	64	64	Yes
Imus River	TSS	mg/L	3	0.67	0.55	1.6	1.5	1.5	Yes
Labangan River	BOD	mg/L	6	1.7	1	2.6	2.5	2.5	Yes
Labangan River	DO	mg/L	3	1.5	1.2	1.9	1.9	1.9	Yes
Labangan River	Fecal Coliform	MPN/100mL	3	330	110	410	400	400	Yes
Labangan River	Nitrate	mg/L	3	0.054	0.043	0.066	0.065	0.065	Yes
Labangan River	Phosphate	mg/L	3	8.8	8.4	16	15	15	Yes
Labangan River	TSS	mg/L	3	0.39	0.29	0.67	0.64	0.64	Yes
Las Pinas-Paranaque River System	BOD	mg/L	3	6.2	6	8.6	8.4	8.4	Yes
Las Pinas-Paranaque River System	DO	mg/L	3	38	7.5	63	60	60	Yes
Las Pinas-Paranaque River System	Fecal Coliform	MPN/100mL	3	220000	110000	250000	250000	250000	Yes
Las Pinas-Paranaque River System	Nitrate	mg/L	3	0.041	0.027	0.06	0.058	0.058	Yes
Las Pinas-Paranaque River System	Phosphate	mg/L	3	90	71	91	91	91	Yes
Las Pinas-Paranaque River System	TSS	mg/L	1	0.69	0.69	0.69	0.69	0.69	Yes
Madlum River	BOD	mg/L	3	0.46	0.45	0.65	0.63	0.63	Yes
Madlum River	DO	mg/L	1	0.7	0.7	0.7	0.7	0.7	Yes
Madlum River	Fecal Coliform	MPN/100mL	1	56	56	56	56	56	Yes
Madlum River	Nitrate	mg/L	1	0.034	0.034	0.034	0.034	0.034	Yes
Madlum River	Phosphate	mg/L	1	2.8	2.8	2.8	2.8	2.8	Yes
Madlum River	TSS	mg/L	1	0.22	0.22	0.22	0.22	0.22	Yes
Marikina River	BOD	mg/L	13	3.6	1.7	6	5.2	5.2	Yes
Marikina River	DO	mg/L	8	1.4	0.99	2.3	2.3	2.3	Yes
Marilao River	BOD	mg/L	21	4.2	1.2	7.4	6.4	6.4	Yes
Marilao River	DO	mg/L	22	2.4	0.93	6.3	5.2	5.2	Yes
Marilao River	Fecal Coliform	MPN/100mL	3	9300	8500	12000	12000	12000	Yes
Marilao River	Nitrate	mg/L	3	0.067	0.044	0.076	0.075	0.075	Yes
Marilao River	Phosphate	mg/L	3	74	48	76	76	76	Yes
Marilao River	TSS	mg/L	3	0.41	0.29	0.51	0.5	0.5	Yes
Meycauayan River	BOD	mg/L	21	8.4	5.1	21	17	17	Yes
Meycauayan River	DO	mg/L	22	4.4	0.73	100	11	11	Yes
Meycauayan River	Fecal Coliform	MPN/100mL	3	30000	29000	370000	340000	340000	Yes
Meycauayan River	Nitrate	mg/L	3	0.033	0.024	0.06	0.057	0.057	Yes
Meycauayan River	Phosphate	mg/L	3	73	61	77	77	77	Yes
Meycauayan River	TSS	mg/L	3	0.39	0.35	0.4	0.4	0.4	Yes
Meycauayan River	microplastics	pc/m3	2	96	0.64	190	180	180	Yes
Meycauayan-Valenzuela River System	BOD	mg/L	10	9.6	5.8	11	11	11	Yes
Meycauayan-Valenzuela River System	DO	mg/L	12	6.1	1.3	100	73	73	Yes

Meycauayan-Valenzuela River System	Fecal Coliform	MPN/100mL	3	180000	110000	100000 0	960000	960000	Yes
Meycauayan-Valenzuela River System	Nitrate	mg/L	2	0.032	0.01	0.054	0.052	0.052	Yes
Meycauayan-Valenzuela River System	Phosphate	mg/L	2	76	55	97	95	95	Yes
Meycauayan-Valenzuela River System	TSS	mg/L	1	0.59	0.59	0.59	0.59	0.59	Yes
Naguilian River System	BOD	mg/L	4	0.32	0.28	0.56	0.53	0.53	Yes
Naguilian River System	DO	mg/L	1	0.54	0.54	0.54	0.54	0.54	Yes
Naguilian River System	Fecal Coliform	MPN/100mL	1	16	16	16	16	16	Yes
Naguilian River System	Nitrate	mg/L	1	0.061	0.061	0.061	0.061	0.061	Yes
Naguilian River System	Phosphate	mg/L	1	3.6	3.6	3.6	3.6	3.6	Yes
Naguilian River System	TSS	mg/L	1	0.2	0.2	0.2	0.2	0.2	Yes
NMTT River System	BOD	mg/L	6	6	4.9	7.1	7	7	Yes
NMTT River System	DO	mg/L	20	2.8	1.4	100	100	100	Yes
NMTT River System	Fecal Coliform	MPN/100mL	3	170000	55000	240000	230000	230000	Yes
NMTT River System	Nitrate	mg/L	3	0.063	0.033	0.14	0.13	0.13	Yes
NMTT River System	Phosphate	mg/L	3	57	55	72	71	71	Yes
NMTT River System	TSS	mg/L	1	0.64	0.64	0.64	0.64	0.64	Yes
Obando River	BOD	mg/L	13	4.4	1.4	22	12	12	Yes
Obando River	DO	mg/L	14	1.8	0.96	3.8	3.7	3.7	Yes
Obando River	Fecal Coliform	MPN/100mL	3	710	510	2100	2000	2000	Yes
Obando River	Nitrate	mg/L	3	0.041	0.021	0.057	0.056	0.056	Yes
Obando River	Phosphate	mg/L	3	29	29	180	160	160	Yes
Obando River	TSS	mg/L	3	0.35	0.3	0.37	0.37	0.37	Yes
Pampanga River	BOD	mg/L	17	1.3	0.25	7.5	4.3	4.3	Yes
Pampanga River	DO	mg/L	21	0.93	0.69	1.7	1.5	1.5	Yes
Pampanga River	Fecal Coliform	MPN/100mL	3	110	100	140	140	140	Yes
Pampanga River	Nitrate	mg/L	3	0.094	0.056	0.16	0.15	0.15	Yes
Pampanga River	Phosphate	mg/L	3	10	7.2	10	10	10	Yes
Pampanga River	TSS	mg/L	3	0.66	0.48	0.83	0.82	0.82	Yes
Pansipit River	BOD	mg/L	13	0.33	0.17	0.81	0.73	0.73	Yes
Pansipit River	DO	mg/L	13	0.75	0.59	1.2	1.1	1.1	Yes
Pansipit River	Fecal Coliform	MPN/100mL	3	7	2.8	21	19	19	Yes
Pansipit River	Nitrate	mg/L	3	0.061	0.05	0.071	0.07	0.07	Yes
Pansipit River	Phosphate	mg/L	3	29	26	32	32	32	Yes
Pansipit River	TSS	mg/L	3	0.28	0.17	0.33	0.33	0.33	Yes
Paranaque River	BOD	mg/L	20	6.1	4.2	8.7	8.4	8.4	Yes
Paranaque River	DO	mg/L	23	5.6	1.5	100	100	100	Yes
Paranaque River	Fecal Coliform	MPN/100mL	2	300000	250000	360000	350000	350000	Yes
Paranaque River	Nitrate	mg/L	2	0.076	0.06	0.093	0.091	0.091	Yes
Paranaque River	Phosphate	mg/L	2	62	17	110	100	100	Yes
Paranaque River	TSS	mg/L	1	0.58	0.58	0.58	0.58	0.58	Yes
Paranaque River	microplastics	pc/m3	2	50	17	84	80	80	Yes
Pasig River	BOD	mg/L	11	3.5	1.5	8.1	8	8	Yes
Pasig River	DO	mg/L	14	1.7	1	2.3	2.3	2.3	Yes

Pasig River	microplastics	pc/m3	3	11	0.0044	57	52	52	Yes
Pinacanauan de Tuguigarao	BOD	mg/L	5	0.16	0.15	0.21	0.21	0.21	No
Pinacanauan de Tuguigarao	DO	mg/L	8	0.62	0.34	0.89	0.83	0.83	No
Pinacanauan de Tuguigarao	Fecal Coliform	MPN/100mL	1	0.5	0.5	0.5	0.5	0.5	No
Pinacanauan de Tuguigarao	Nitrate	mg/L	1	0.017	0.017	0.017	0.017	0.017	No
Pinacanauan de Tuguigarao	Phosphate	mg/L	1	1.6	1.6	1.6	1.6	1.6	No
Pinacanauan de Tuguigarao	TSS	mg/L	1	0.074	0.074	0.074	0.074	0.074	No
Pinamalayan River	BOD	mg/L	5	0.7	0.54	1.8	1.7	1.7	No
Pinamalayan River	DO	mg/L	2	1.2	1	1.3	1.3	1.3	No
Pinamalayan River	Fecal Coliform	MPN/100mL	2	72	16	130	120	120	No
Pinamalayan River	Nitrate	mg/L	2	0.073	0.049	0.097	0.095	0.095	No
Pinamalayan River	Phosphate	mg/L	2	5.2	4.8	5.6	5.6	5.6	No
Pinamalayan River	TSS	mg/L	2	0.2	0.2	0.21	0.21	0.21	No
Pugo River	BOD	mg/L	5	0.19	0.18	0.2	0.2	0.2	Yes
Pugo River	Fecal Coliform	MPN/100mL	2	130	25	240	230	230	Yes
Pugo River	Nitrate	mg/L	2	0.68	0.21	1.2	1.1	1.1	Yes
Pugo River	Phosphate	mg/L	2	2	2	2	2	2	Yes
Pugo River	TSS	mg/L	2	0.11	0.062	0.15	0.15	0.15	Yes
Rio Grande River	BOD	mg/L	10	0.84	0.52	1.4	1.2	1.2	Yes
Rio Grande River	DO	mg/L	11	0.82	0.76	1.1	1	1	Yes
Rio Grande River	Fecal Coliform	MPN/100mL	3	670	520	1000	1000	1000	Yes
Rio Grande River	Nitrate	mg/L	3	0.31	0.22	0.45	0.44	0.44	Yes
Rio Grande River	Phosphate	mg/L	3	41	33	45	45	45	Yes
Rio Grande River	TSS	mg/L	3	0.69	0.44	0.79	0.78	0.78	Yes
San Juan River System	BOD	mg/L	13	7.8	4.8	11	10	10	Yes
San Juan River System	DO	mg/L	18	3.7	1.6	100	100	100	Yes
San Juan River System	Fecal Coliform	MPN/100mL	3	350000	150000	650000	620000	620000	Yes
San Juan River System	Nitrate	mg/L	3	0.026	0.016	0.046	0.044	0.044	Yes
San Juan River System	Phosphate	mg/L	3	93	88	97	96	96	Yes
San Juan River System	TSS	mg/L	1	0.57	0.57	0.57	0.57	0.57	Yes
San Miguel River	BOD	mg/L	3	0.92	0.52	1.4	1.4	1.4	Yes
San Miguel River	DO	mg/L	1	0.86	0.86	0.86	0.86	0.86	Yes
San Miguel River	Fecal Coliform	MPN/100mL	1	560	560	560	560	560	Yes
San Miguel River	Nitrate	mg/L	1	0.064	0.064	0.064	0.064	0.064	Yes
San Miguel River	Phosphate	mg/L	1	6.8	6.8	6.8	6.8	6.8	Yes
San Miguel River	TSS	mg/L	1	0.77	0.77	0.77	0.77	0.77	Yes
Sinocalan River	BOD	mg/L	1	0.73	0.73	0.73	0.73	0.73	Yes
Sinocalan River	DO	mg/L	1	0.86	0.86	0.86	0.86	0.86	Yes
Sinuculan-Dagupan River	BOD	mg/L	7	0.61	0.54	1.7	1.6	1.6	Yes
Sinuculan-Dagupan River	DO	mg/L	8	0.89	0.74	0.96	0.96	0.96	Yes
Sinuculan-Dagupan River	Fecal Coliform	MPN/100mL	1	44	44	44	44	44	Yes
Sinuculan-Dagupan River	Nitrate	mg/L	1	0.066	0.066	0.066	0.066	0.066	Yes
Sinuculan-Dagupan River	Phosphate	mg/L	1	16	16	16	16	16	Yes

Sinuculan-Dagupan River	TSS	mg/L	1	0.23	0.23	0.23	0.23	0.23	Yes
Sta Maria River	BOD	mg/L	17	2.2	1.1	6.7	5.2	5.2	Yes
Sta Maria River	DO	mg/L	19	1.7	0.75	3.8	2.9	2.9	Yes
Sta Maria River	Fecal Coliform	MPN/100mL	3	1200	580	4800	4400	4400	Yes
Sta Maria River	Nitrate	mg/L	3	0.11	0.053	0.16	0.16	0.16	Yes
Sta Maria River	Phosphate	mg/L	3	80	49	180	170	170	Yes
Sta Maria River	TSS	mg/L	3	0.32	0.28	0.37	0.36	0.36	Yes
Talisay River	BOD	mg/L	13	0.81	0.29	1.7	1.6	1.6	Yes
Talisay River	DO	mg/L	13	0.94	0.75	1.5	1.4	1.4	Yes
Talisay River	Fecal Coliform	MPN/100mL	2	460	400	530	520	520	Yes
Talisay River	Nitrate	mg/L	3	0.05	0.04	0.067	0.065	0.065	Yes
Talisay River	Phosphate	mg/L	3	4.8	4.4	4.8	4.8	4.8	Yes
Talisay River	TSS	mg/L	3	0.28	0.26	0.41	0.4	0.4	Yes
Tullahan River	microplastics	pc/m3	2	110	38	190	180	180	Yes
Upper Chico River	BOD	mg/L	3	0.22	0.21	0.3	0.29	0.29	No
Upper Chico River	Fecal Coliform	MPN/100mL	2	150	90	200	200	200	No
Upper Chico River	Nitrate	mg/L	2	2.4	0.0057	4.8	4.5	4.5	No
Upper Chico River	Phosphate	mg/L	2	2	1.6	2.4	2.4	2.4	No
Upper Chico River	TSS	mg/L	2	0.33	0.21	0.44	0.43	0.43	No
Ylang-Ylang River	BOD	mg/L	17	3.2	0.7	18	18	18	Yes
Ylang-Ylang River	DO	mg/L	16	1	0.81	1.3	1.2	1.2	Yes
Ylang-Ylang River	Fecal Coliform	MPN/100mL	3	920	910	1400	1300	1300	Yes
Ylang-Ylang River	Nitrate	mg/L	3	0.22	0.22	0.33	0.32	0.32	Yes
Ylang-Ylang River	Phosphate	mg/L	3	41	39	71	68	68	Yes
Ylang-Ylang River	TSS	mg/L	3	0.63	0.62	2.5	2.3	2.3	Yes

Note: RQ_median – median of RQ values

RQ_min – minimum from the RQ values

RQ_max – maximum from the RQ values

RQ_p95 – 95th percentile of the computed values

RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

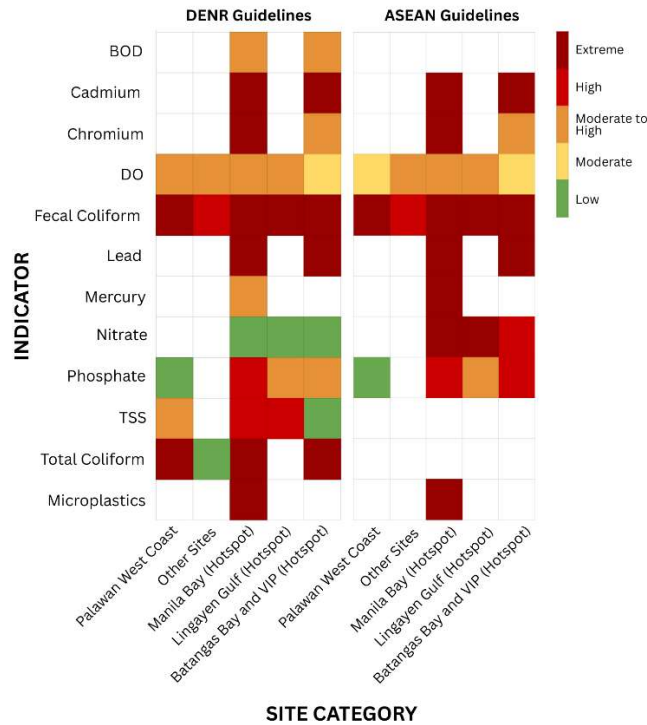


Figure 3.1.1. Heat Map for Pollution Hotspots using the 95th Percentile Risk Quotient

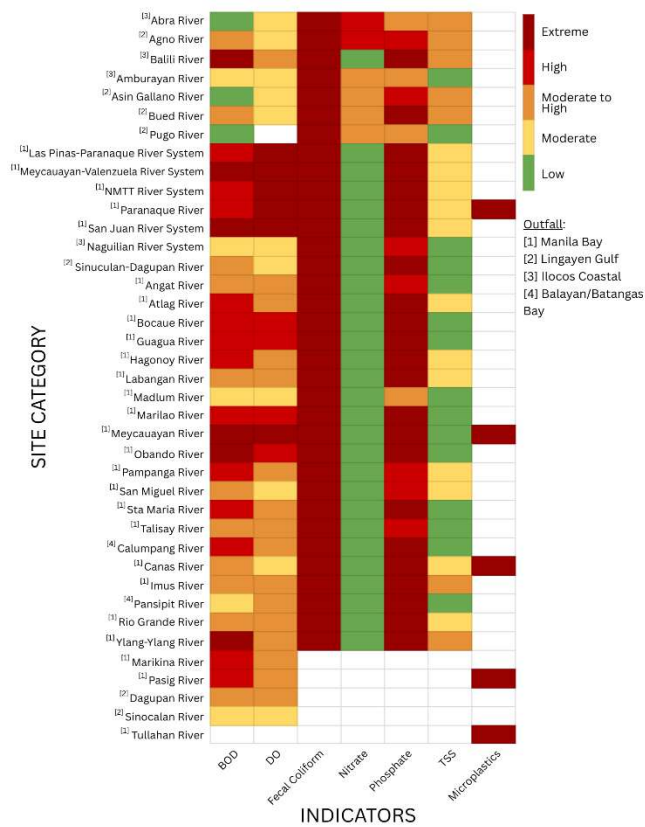


Figure 3.1.2. Heat Map for Rivers Draining to the Philippine Waters of SCS-LME using the 95th Percentile Risk Quotient.

Annex 3.J. Output from the Multi-stakeholder Validation Workshop

The validation workshop for the Pollution Component of the Philippine Transboundary Diagnostic Analysis (TDA) was convened to validate results from the collated data, refine analytical findings, and identify remaining gaps in assessing pollution pressures on the South China Sea Large Marine Ecosystem (SCS-LME). The session brought together representatives from the Environmental Management Bureau (EMB), Philippine Coast Guard (PCG), Biodiversity Management Bureau (BMB), Laguna Lake Development Authority (LLDA), Manila Bay Coordinating Office (MBCO), and civil society organizations, among others. The discussion emphasized the need to strengthen the evidence-informed governance and to harmonize institutional roles in monitoring, reporting, and regulating multiple pollution sources.

Stakeholders confirmed that domestic wastewater remains the dominant contributor to national pollution loads, reflecting low sewerage coverage and persistent untreated discharges into rivers and coastal waters. EMB and LLDA emphasized that the domestic sector continues to exceed other source categories in nutrient, organic, and pathogen loading. Nonpoint sources, particularly agricultural runoff, sedimentation from upland erosion and other land-based activities, and diffuse nutrient discharges, were also identified as significant sources but poorly quantified, with limited available datasets on nitrogen, phosphorus, and sediment load calculations. EMB noted ongoing work to develop sediment quality guidelines.

The workshop also validated the contribution of aquaculture and mariculture operations as emerging sources of pollution, especially in semi-enclosed bays. However, participants underscored weak coordination between DA BFAR and DENR EMB in monitoring aquaculture effluents, resulting in fragmented datasets and limited reporting of environmental quality attributed to aquaculture/mariculture activities. For industrial effluent and hazardous wastes, EMB highlighted ongoing efforts to improve data systems, including the development of industry-specific pollution load databases and disaggregated hazardous waste inventories from different sources. During the validation workshop, it was noted that confidence in reported hazardous waste data has been improved since 2020 with the operationalization of the online Hazardous Waste Management System (<https://hwms.emb.gov.ph>). Key features include online registration for these different entities, an interface to enter regulatory compliance data, and reports to track hazardous waste volumes and movements.

The Philippine Coast Guard identified incomplete oil spill datasets, particularly for minor spill events after 2022. A formal request from PCG was recommended to access the full oil spill inventory for the most recent years if needed. Though the Philippine Archipelagic Sea Lanes Act (RA 12065) has recently been enacted and stipulated the prohibition of marine pollution that includes oil discharges and ballast water, the absence of Implementing Rules and Regulations (IRR) also emerged as a critical gap, with implications for both chemical and biological pollution, including invasive alien species from ballast water from ships.

Participants validated four major pollution hotspots: Manila Bay, Lingayen Gulf, Batangas Bay–Verde Island Passage (VIP), and the west coast of Palawan. These areas exhibit exceedances in microbial contaminants, nutrients, and industrial pollutants, and are considered priority locations for management intervention, given the reasonable worst-case scenario. DENR Manila Bay Coordinating Office and DENR EMB Regional Offices (e.g., Region 4A and 4B) are willing to provide recent data to supplement the analysis in Batangas Bay and the west coast of Palawan. It was also mentioned during the workshop that several letters of request had already been sent to pertinent government agencies during the study's conduct for such data.

Batangas Bay and VIP

Nitrate concentrations have exceeded ASEAN Water Quality Guidelines (WQG) thresholds post-validation but remain compliant within the DENR WQG standards. Pre-validation data has indicated potential phosphate

concerns in Batangas Bay and VIP hotspot; however, these assessments were based on only two data points. Subsequent validation revealed that phosphate levels have actually complied with DENR WQG standards in recent years (2024-2025). Wagas and Andres (2022) reported an increasing trend in heavy metal concentrations exceeding thresholds in Batangas Bay. The recent monitoring data (2024-2025) indicates that chromium concentrations have complied with DENR WQG standards. However, caution must be exercised when interpreting these data, as the parameters can be subjected to factors such as seasonal variability.

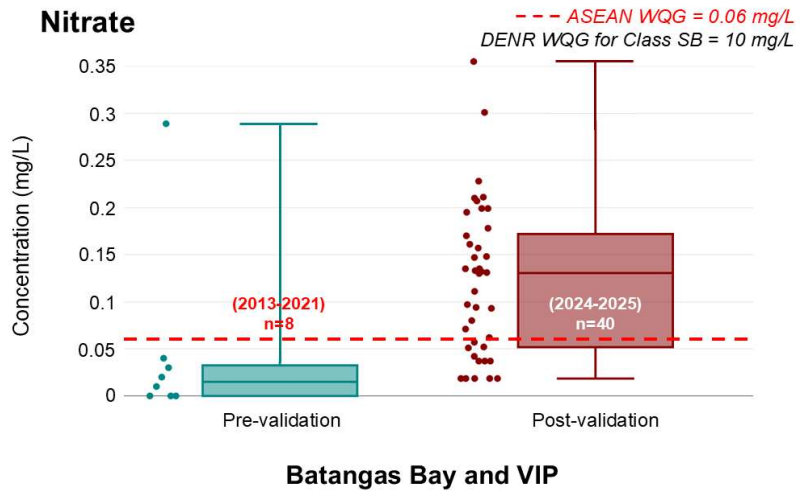


Figure 3.J.1. Box Plot for Nitrate Concentration in Batangas Bay (Pre- and Post-Validation)

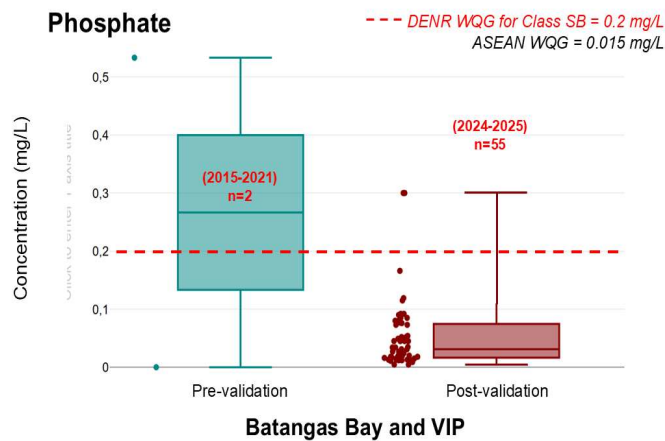


Figure 3.J.2. Box Plot for Phosphate Concentration in Batangas Bay (Pre- and Post-Validation)

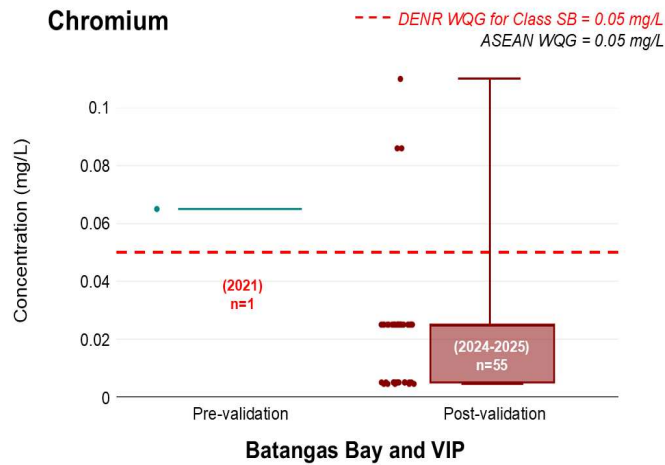


Figure 3.J.3. Box Plot for Chromium Concentration in Batangas Bay (Pre- and Post-Validation)

West Coast of Palawan

Generally, TSS levels in the west coast of Palawan falls in compliance to the DENR WQG for Class SB. Although there is a notable change in the trend for TSS concentration in Palawan (post-validation) where a significant number exceeds the DENR WQG, some in extreme exceedances. Siltation from rivers and anthropogenic activities such as quarrying may have caused the increased TSS levels. Enhanced monitoring as well as appropriate intervention is recommended, as TSS affects light penetration which in turn affects productivity in marine ecosystems. Similarly, caution must be exercised in interpreting due to the aggregation of data, as the parameter can be subjected to factors such as seasonal variability.

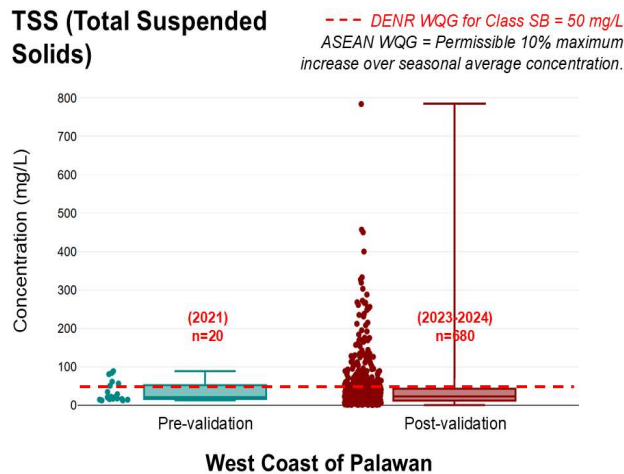


Figure 3.J.4. Box Plot for Total Suspended Solids Concentration in the west coast of Palawan (Pre- and Post-Validation)

Lingayen Gulf

Acquiring data for water quality in Lingayen Gulf remains a challenge due to limited accessibility. Following validation, the EMB Region 1 provided fecal coliform concentration data, significantly enhancing the reliability of data assessment. These post-validation data, which address previous data scarcity, reveal findings that contrast with

earlier assessments. Fecal coliform levels in Lingayen Gulf generally comply with DENR Water Quality Guidelines for Class SB waters (100 MPN/100 mL), though notable exceedances occurred between 2014-2025. While results are encouraging, they underscore the need for stricter regulation and continuous monitoring to maintain compliance.

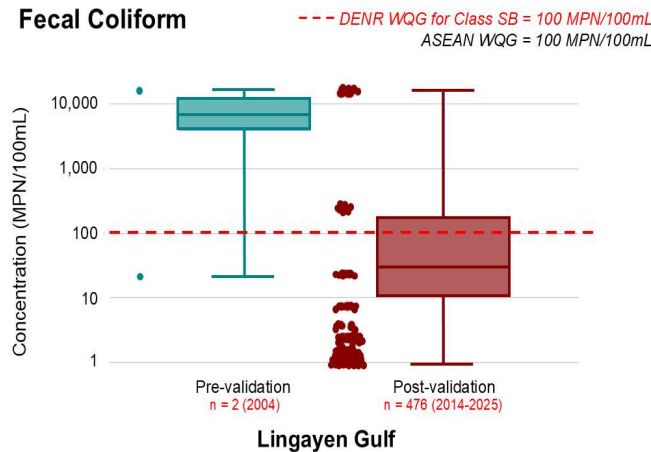


Figure 3.J.5. Box Plot for Fecal Coliform Concentration in Lingayen Gulf (Pre- and Post-Validation)

Risk Assessment

A similar risk assessment was done using the dataset provided by the concerned agencies (Figure 3.J.6). Nitrate levels for the hotspots remain a low to moderate concern, but increase in monitoring should be prioritized in the rivers draining to Manila Bay. Phosphate, BOD, DO, and TSS levels in Manila Bay (coastal and from riverine inputs) remain high to extreme risk, solidifying its position as the most critical hotspot. Despite ongoing Manila Bay rehabilitation efforts mandated by the Supreme Court, it continues to face significant environmental challenges. Enhanced water quality monitoring, stricter enforcement of environmental regulations, and increased stakeholder engagement remain essential for meaningful progress. The risk for phosphate and chromium in Batangas Bay is lowered to moderate using the dataset provided by the EMB region 4A, compared to the moderate to high risk from the previous heat map (due to limited data). However, the risk for TSS levels has increased from low to moderate, which could be attributed to the industrial activities surrounding the area. Coliform levels remain problematic for all hotspots, which could be due to the limited connections of households to sewage and septage systems in the national level. If this continues, the elevated levels of coliform would become a threat not only to the marine ecosystems but also pose risk to public health. Following the ASEAN guidelines reflect moderate to extreme risks for most indicators due to a more conservative threshold as it was developed in consideration to aquatic life protection, compared to the DENR guidelines which was developed for a waterbody's intended use aside from ecosystem health. The additional data points have significantly increased the accuracy of the risk assessment for Batangas Bay and VIP area, Lingayen Gulf, Manila Bay, and the west coast of Palawan, with significant addition of the coasts of Ilocos.

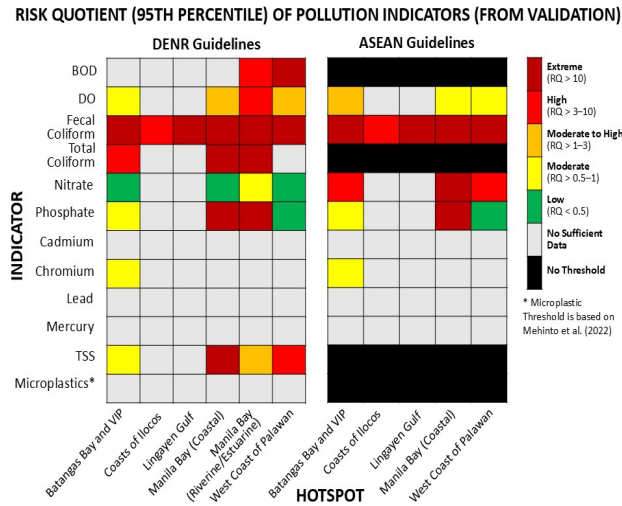


Figure 3.J.6. Heat Map for Pollution Hotspots (Post-validation) in the Philippine Waters of SCS-LME (2011-2025)

Water Quality Index (WQI) of Manila Bay

To date, the DENR EMB has no existing guidelines on measuring marine or coastal water quality index. Water quality indices provide a simplified, standardized metric for assessing complex datasets through qualitative categories such as "poor," "moderate," and "good." To evaluate coastal water quality in Manila Bay, the Canadian Council of Ministers of the Environment (CCME) Water Quality Index was applied. The CCME WQI was selected for its simplicity and flexibility in handling missing data and parameters, treating all variables with equal weight. However, this approach is susceptible to bias, particularly with incomplete parameter and temporal datasets as in the case of this assessment for Manila Bay. Despite the limitation, this assessment is necessary for communicating the water quality status of Manila Bay effectively.

Table 3.J.1. CCME WQI Category

Rating	Value	Definition
Excellent	95-100	water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
Good	80-94	water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	65-79	water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45-64	water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor	0-44	water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

As provided by the Manila Bay Coordinating Office, a total of 5,386 datapoints and six parameters (DO, fecal coliform, total coliform, nitrate, phosphate, and TSS) were considered in computing for the CCME WQI. Figure 3.J.7 presents the time-series of water quality in Manila Bay assessed using the CCME WQI. A gradual upward trend is observed, potentially attributed to the rehabilitation efforts mandated by the Supreme Court mandamus. However, annual WQI values consistently fall within the "poor" category (Table 3.J.2), indicating that most parameters fail to meet DENR Water Quality Guidelines (see Table 3.J.7 for detailed calculations). The highest WQI value occurs in

2025 at 27, followed by 2017 at 24; notably, the 2025 value are subject to change as monitoring continues through year-end.

Consistent with the TDA report findings, these results reflect Manila Bay's location within the nation's most densely populated region. Given that domestic wastewater and solid waste are among the primary sources of pollution, wherein both are directly affected by population, the persistently poor water quality highlights the immediate need for more effective rehabilitation strategies to protect the marine ecosystems and sustain the livelihoods of communities dependent on Manila Bay's natural resources.

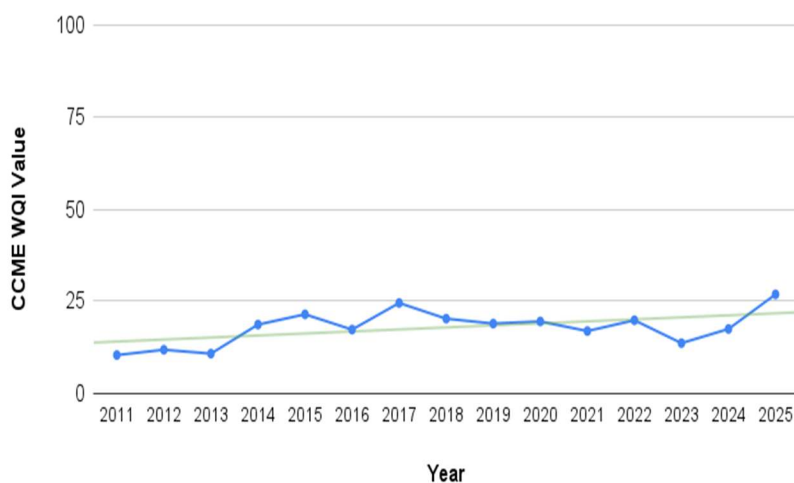


Figure 3.J.7. Time Series of CCME WQI Values in Manila Bay (2011-2025)

Table 3.J.2. CCME WQI Rating in Manila Bay from 2011-2025

Spatial Coverage	Year	CCME WQI Value	Rating
Manila Bay (Coastal)	2011	10	Poor
Manila Bay (Coastal)	2012	12	Poor
Manila Bay (Coastal)	2013	11	Poor
Manila Bay (Coastal)	2014	19	Poor
Manila Bay (Coastal)	2015	21	Poor
Manila Bay (Coastal)	2016	17	Poor
Manila Bay (Coastal)	2017	24	Poor
Manila Bay (Coastal)	2018	20	Poor
Manila Bay (Coastal)	2019	19	Poor
Manila Bay (Coastal)	2020	19	Poor
Manila Bay (Coastal)	2021	17	Poor
Manila Bay (Coastal)	2022	20	Poor
Manila Bay (Coastal)	2023	14	Poor
Manila Bay (Coastal)	2024	17	Poor
Manila Bay (Coastal)	2025	27	Poor

Several emerging pollution issues were also validated and identified, including those related to antimicrobial resistance (AMR), e-waste and other emerging hazardous waste streams, noise pollution from maritime activities, and the transport of other pollutants attached to microplastics. EMB also highlighted ongoing national initiatives to

enhance marine litter monitoring, including the development of a marine debris profiling database and the implementation of the Marine Litter Management Project in Manila Bay.

To complement the national consultation workshops, a structured validation survey was conducted to systematically capture stakeholder perspectives on (a) priority causes of land-based pollution, (b) major pollution sources and pathways, and (c) perceived transboundary pollution concerns affecting the Philippine waters of the South China Sea Large Marine Ecosystem (SCS-LME) (d) gaps and challenges in pollution control and management, and (e) recommended priority actions. There is a total of twenty-five (25) respondents from multiple stakeholders, in which majority are from the government (19 respondents), followed by respondents from NGO and civil society (6), two respondents are from the community group/fisherfolk organization and one respondent from the academic/research institution.

Affiliation

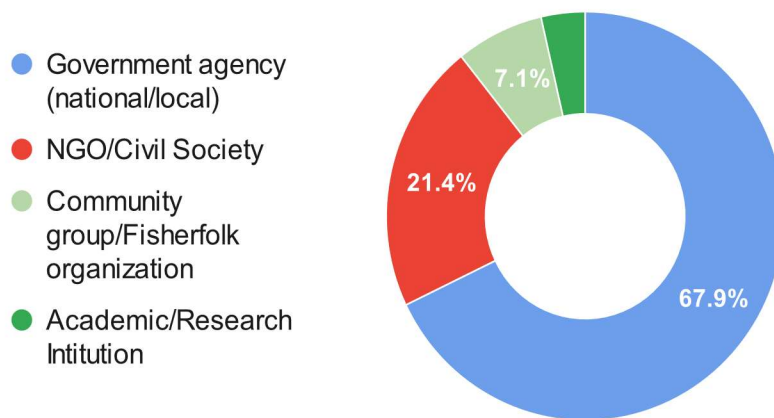


Figure 3.J.8. Composition of Stakeholders' Affiliation

Root Cause

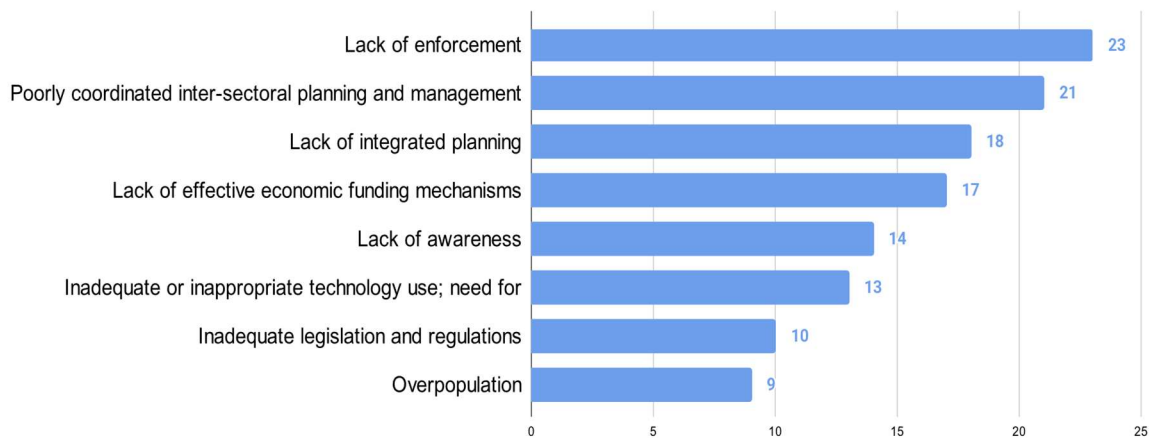


Figure 3.J.9. Ranking of Root Causes of Pollution

Twenty-three respondents have chosen lack of enforcement among their top five root cause, followed by poorly coordinated inter-sectoral planning and management (21 respondents), lack of integrated planning (18), lack of effective funding mechanisms (17), and lack of awareness (14). The five primary root causes of land-based pollution

reflect systemic governance challenges. Respondents indicated that existing environmental laws is adequate; however, enforcement and implementation remain lacking. There is gap in environmental awareness existing within communities, with some LGU officials unfamiliar with environmental laws. To address these challenges, some respondents recommended implementing incentives to promote behavioral change, alongside strengthening environmental programs and activities. This suggests that effective pollution control requires not only regulatory frameworks but also comprehensive awareness campaigns, institutional and intentional capacity building, and positive reinforcement strategies to encourage compliance and sustainable practices.

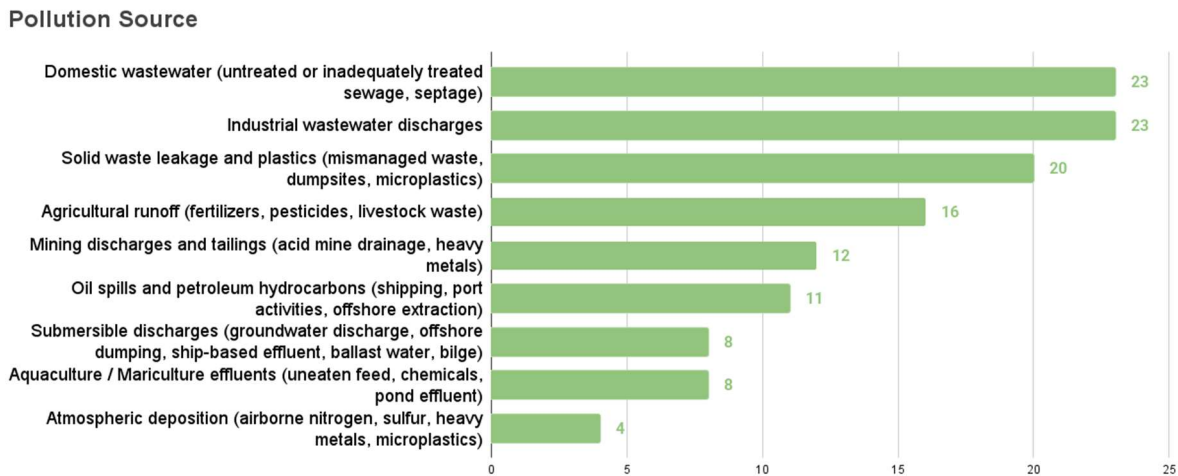


Figure 3.J.10. Ranking of Pollution Sources

Wastewater discharge (domestic and industrial) remains the top contributor of pollution especially to marine waters (23 respondents each), followed by solid waste and plastic leakage (20 respondents), and agricultural source (16 respondents). This validation survey has further strengthened and supported the findings of the TDA report. Mining discharges and tailings (12 respondents) was also considered as a major contributor to pollution. However, data is limited to accurately assess the impact of mining activities and remains a significant knowledge gap.

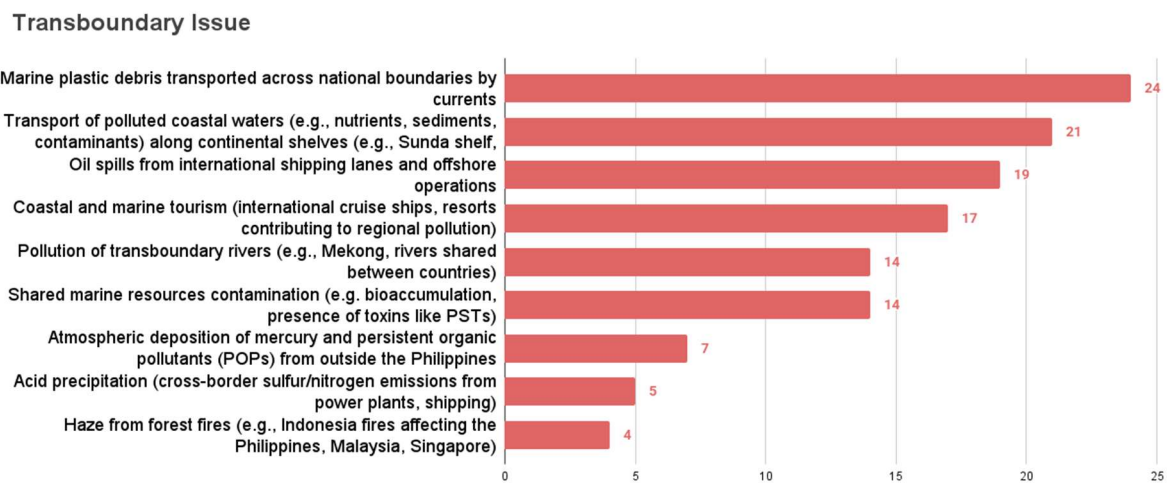


Figure 3.J.11. Primary Transboundary Issues for Pollution

The results of the validation survey support the transboundary issues presented in the TDA report. With marine plastic debris transport as the top transboundary issue (22 respondents). However, the respondents (17) also identified the increasing coastal and marine tourism-related activities as among the top five transboundary issue. This warrants consideration to develop appropriate regulations and management strategies concerning the developing coastal tourism sector among countries.

Gaps and Priority Challenges

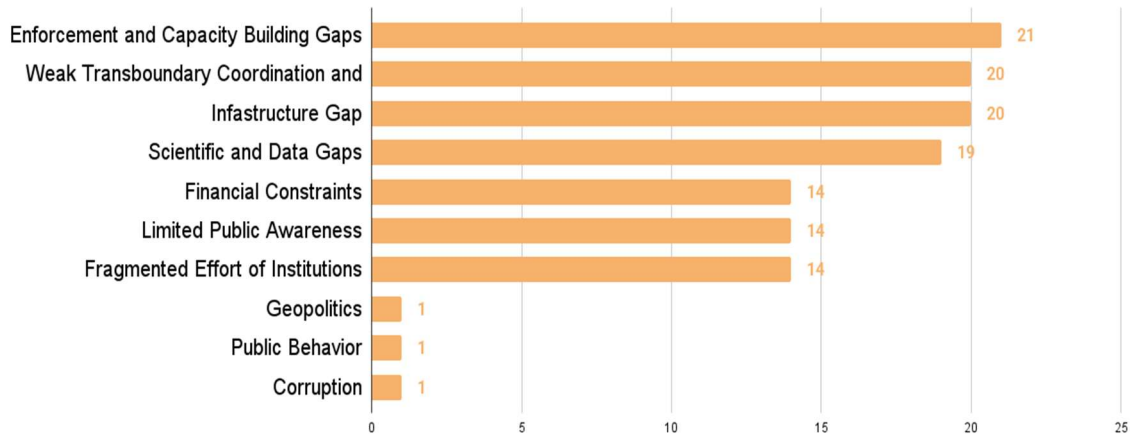


Figure 3.J.12. Gaps and Priority Challenges in Pollution Mitigation

Priority Actions

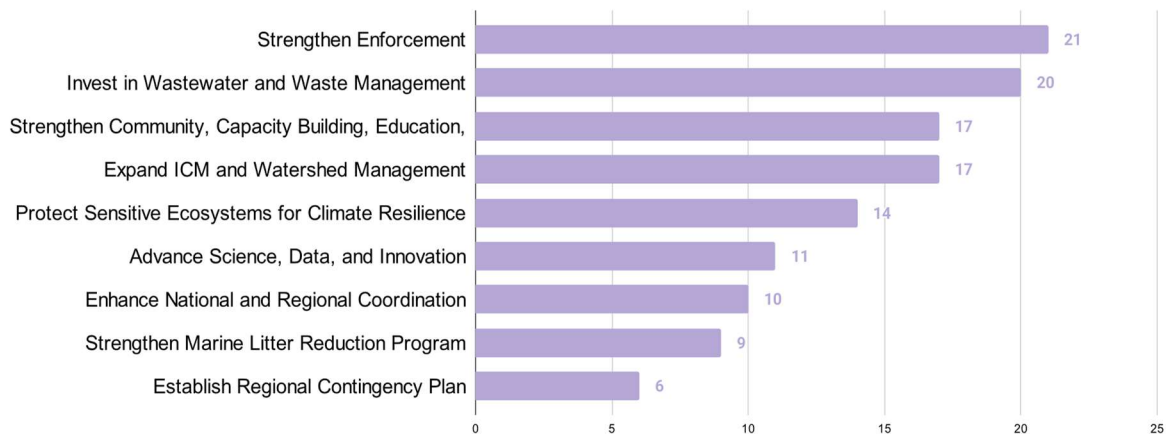


Figure 3.J.13. Priority Actions in Pollution Mitigation

Enforcement and capacity building gap is considered as the top priority challenge by 21 respondents. This is followed by weak transboundary cooperation and infrastructure gaps (20 respondents each). Scientific and data gaps (19), financial constraints (14), limited public awareness (14), and fragmented effort of institutions (14) are also considered. As mentioned, existing environmental laws are adequate and comprehensive, the apparent problem lies to enforcement and implementation. Infrastructure gaps can be connected to financial constraints. Scientific and data gaps are also highlighted that could result to the lack of public awareness. To answer these challenges, the respondents also identified the top priority actions. Strengthening enforcement (21 respondents) emerges as the top priority to address pollution. Investing to wastewater treatment infrastructure follows (20), reflecting the significance of domestic

wastewater as the top contributor to land-based pollution. Strengthening CEPA activities (17 respondents) addresses the gap in public awareness. It is followed by the expansion of ICM and watershed management (17) and protection of sensitive ecosystems for climate resilience (14) which not only addresses pollution but also contributes to the ecosystem services in which the population within the SCS-LME can benefit from.

Overall, the workshop affirmed the robustness of the initial update to TDA, while emphasizing the need for strengthened interagency coordination, improved data accessibility, and updated datasets to address information gaps. The consolidated feedback will guide the refinement of the TDA and the integration of validated evidence and recommendations into the final TDA.

Table 3.J.3. Summary Table for Number of Available Data on Water Quality by Pollution Hotspot (Post-Validation)

Coastal Pollution Hotspots	BOD	DO	Fecal Coliform	Total Coliform	Cadmium	Chromium	Lead	Mercury	Nitrate	Phosphate	TSS	Micro-plastics
Batangas Bay and VIP	0	0	55	35	40	0	0	40	55	30	40	0
Coasts of Ilocos	0	0	0	0	321	0	0	0	0	0	0	0
Lingayen Gulf (Hotspot)	0	0	0	0	476	0	0	0	0	0	0	0
Manila Bay (Coastal)	0	0	0	310	438	0	0	219	225	269	154	0
Manila Bay (Riverine/Estuarine)	402	0	0	701	714	0	0	675	721	708	287	0
West Coast of Palawan	0	44	81	4	0	0	0	0	0	20	20	0

Table 3.J.4 Descriptive Statistics for Water Quality on Pollution Hotspots (Post-Validation)

Coastal Pollution Hotspots	Indicator	unit	count	mean	std	median	q25	q75	p5	p95	min	max
Batangas Bay and VIP	Nitrate	mg/L	40	0.12	0.081	0.13	0.052	0.17	0.019	0.23	0.019	0.36
Batangas Bay and VIP	Phosphate	mg/L	55	0.052	0.059	0.031	0.017	0.075	0.01	0.13	0.0045	0.3
Batangas Bay and VIP	DO	mg/L	35	6.6	0.74	6.6	6.5	6.8	5.5	7.6	4	8
Batangas Bay and VIP	TSS	mg/L	30	26	12	24	17	32	12	41	10	68
Batangas Bay and VIP	Total Coliform	MPN/100 mL	40	9400	27000	1000	350	4000	32	36000	6.1	160000
Batangas Bay and VIP	Fecal Coliform	MPN/100 mL	40	1000	2700	210	39	720	8.8	3600	0.9	16000
Batangas Bay and VIP	Chromium	mg/L	55	0.022	0.02	0.025	0.005	0.025	0.0045	0.043	0.0045	0.11
Coasts of Ilocos	Fecal Coliform	MPN/100 mL	321	240	1500	23	7	76	0.9	540	0.9	24000
Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100 mL	476	560	2100	45	11	170	0.9	1700	0.9	16000
West Coast of Palawan	Nitrate	mg/L	616	0.2	0.08	0.25	0.15	0.25	0.029	0.25	0.005	0.71
West Coast of Palawan	Phosphate	mg/L	679	0.018	0.035	0.01	0.01	0.01	0.01	0.054	0	0.53
West Coast of Palawan	DO	mg/L	787	6.2	1.5	6.4	5.6	7	3.3	8.5	0.51	11
West Coast of Palawan	TSS	mg/L	680	42	64	23	12	43	4	160	0.5	780
West Coast of Palawan	Fecal Coliform	MPN/100 mL	857	24000	550000	79	9	700	0.9	37000	0.9	1.6E+08
West Coast of Palawan	BOD	mg/L	22	33	33	29	12	39	7.1	77	4.5	160
Manila Bay (Coastal)	Nitrate	mg/L	219	190	1600	0.2	0.14	0.3	0.077	1.7	0.027	15000
Manila Bay (Coastal)	Phosphate	mg/L	225	290	2500	0.14	0.085	0.27	0.054	4.1	0.03	22000
Manila Bay (Coastal)	DO	mg/L	310	92	890	5.8	4.2	6.5	2.5	8.7	0.9	10000
Manila Bay (Coastal)	TSS	mg/L	269	2700	13000	74	44	120	13	13000	5	140000
Manila Bay (Coastal)	Total Coliform	MPN/100 mL	154	73000	420000	5700	800	27000	22	480000	1.4	3.3E+08

Manila Bay (Coastal)	Fecal Coliform	MPN/100 mL	438	3.6E+10	7.6E+11	9000	1900	88000	91	22000000	1.7	1.6E+13
Manila Bay (Riverine/Estuarine)	Nitrate	mg/L	675	2	11	0.35	0.2	0.83	0.11	6.1	0.031	250
Manila Bay (Riverine/Estuarine)	Phosphate	mg/L	721	3.9	22	0.83	0.23	1.5	0.11	14	0.031	430
Manila Bay (Riverine/Estuarine)	DO	mg/L	701	110000	1700000	3.9	2.8	5.2	1.7	7	0.42	27000000
Manila Bay (Riverine/Estuarine)	TSS	mg/L	708	46	76	36	25	52	13	100	1.3	1700
Manila Bay (Riverine/Estuarine)	Total Coliform	MPN/100 mL	287	1.6E+09	1.5E+10	350000	51000	1500000	8.1	36000000	3	2E+11
Manila Bay (Riverine/Estuarine)	Fecal Coliform	MPN/100 mL	714	1.3E+09	1.2E+10	930000	22000	11000000	34	4.1E+08	0.49	1.8E+11
Manila Bay (Riverine/Estuarine)	BOD	mg/L	402	2200	38000	25	11	46	3.1	78	1.9	760000

Notes: std = Standard Deviation

p25 = 25th percentile of concentrations

p75 = 75th percentile of concentrations

p5 = 5th percentile of concentrations

p95 = 95th percentile of concentrations

MPN = Most Probable Number

Table 3.J.5. Computed RQs based on DENR Water Quality Standards for Pollution Hotspots (Post-Validation).

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP	Nitrate	mg/L	40	0.013	0.0019	0.036	0.023	0.023
Batangas Bay and VIP	Phosphate	mg/L	55	0.16	0.023	1.5	0.67	0.67
Batangas Bay and VIP	DO	mg/L	35	0.76	0.63	1.3	0.9	0.9
Batangas Bay and VIP	TSS	mg/L	30	0.29	0.13	0.85	0.51	0.51
Batangas Bay and VIP	Total Coliform	MPN/100mL	40	0.2	0.0012	32	7.2	7.2
Batangas Bay and VIP	Fecal Coliform	MPN/100mL	40	1	0.0045	80	18	18
Batangas Bay and VIP	Chromium	mg/L	55	0.5	0.09	2.2	0.87	0.87
Coasts of Ilocos	Fecal Coliform	MPN/100mL	321	0.23	0.009	240	5.4	5.4
Lingayen Gulf	Fecal Coliform	MPN/100mL	476	0.45	0.009	160	17	17
West Coast of Palawan	Nitrate	mg/L	616	0.025	0.0005	0.071	0.025	0.025
West Coast of Palawan	Phosphate	mg/L	679	0.05	0	2.7	0.27	0.27
West Coast of Palawan	DO	mg/L	787	0.94	0.52	12	1.7	1.7
West Coast of Palawan	TSS	mg/L	680	0.46	0.01	16	3.2	3.2
West Coast of Palawan	Fecal Coliform	MPN/100mL	857	0.79	0.009	800000	250	250
West Coast of Palawan	BOD	mg/L	22	4.1	0.64	23	11	11
Manila Bay (Coastal)	Nitrate	mg/L	219	0.02	0.0027	1500	0.17	0.17
Manila Bay (Coastal)	Phosphate	mg/L	225	0.71	0.15	110000	20	20
Manila Bay (Coastal)	DO	mg/L	310	1	0.00059	6.7	2.4	2.4
Manila Bay (Coastal)	TSS	mg/L	269	1.5	0.1	2900	250	250
Manila Bay (Coastal)	Total Coliform	MPN/100mL	154	5.7	0.0014	330000	480	480
Manila Bay (Coastal)	Fecal Coliform	MPN/100mL	438	90	0.017	1.6E+11	220000	220000
Manila Bay (Riverine/Estuarine)	Nitrate	mg/L	675	0.05	0.0022	36	0.75	0.75
Manila Bay (Riverine/Estuarine)	Phosphate	mg/L	721	14	0.035	17000	160	160
Manila Bay (Riverine/Estuarine)	DO	mg/L	701	1.3	0.00000019	12	3	3
Manila Bay (Riverine/Estuarine)	TSS	mg/L	708	0.44	0.016	22	1.2	1.2
Manila Bay (Riverine/Estuarine)	Total Coliform	MPN/100mL	287	70	0.0006	39000000	7200	7200
Manila Bay (Riverine/Estuarine)	Fecal Coliform	MPN/100mL	714	460	0.0025	90000000	1600000	1600000

Manila Bay (Riverine/Estuarine)	BOD	mg/L	402	1.7	0.13	110000	9.7	9.7
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Note: RQ_median - median of RQ values

RQ_min – minimum from the RQ values

RQ_max – maximum from the RQ values

RQ_p95 – 95th percentile of the computed values

RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.J.6. Computed RQs based on ASEAN Water Quality Standards for Pollution Hotspots (Post-Validation).

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP	Nitrate	mg/L	40	2.2	0.31	5.9	3.9	3.9
Batangas Bay and VIP	Phosphate	mg/L	55	0.21	0.03	2	0.89	0.89
Batangas Bay and VIP	DO	mg/L	35	0.61	0.5	1	0.72	0.72
Batangas Bay and VIP	Fecal Coliform	MPN/100mL	40	2.1	0.009	160	36	36
Batangas Bay and VIP	Chromium	mg/L	55	0.5	0.09	2.2	0.87	0.87
Coasts of Ilocos	Fecal Coliform	MPN/100mL	321	0.23	0.009	240	5.4	5.4
Lingayen Gulf	Fecal Coliform	MPN/100mL	476	0.45	0.009	160	17	17
West Coast of Palawan	Nitrate	mg/L	616	4.2	0.083	12	4.2	4.2
West Coast of Palawan	Phosphate	mg/L	679	0.067	0	3.5	0.36	0.36
West Coast of Palawan	DO	mg/L	787	0.63	0.36	9.8	1	1
West Coast of Palawan	Fecal Coliform	MPN/100mL	857	0.78	0.009	350	35	35
Manila Bay (Coastal)	Nitrate	mg/L	219	3.4	0.45	250000	28	28
Manila Bay (Coastal)	Phosphate	mg/L	225	0.94	0.2	150000	27	27
Manila Bay (Coastal)	DO	mg/L	310	0.69	0.0004	4.4	1.6	1.6
Manila Bay (Coastal)	Fecal Coliform	MPN/100mL	438	90	0.017	1.6E+11	220000	220000

Note: RQ_median - median of RQ values

RQ_min – minimum from the RQ values

RQ_max – maximum from the RQ values

RQ_p95 – 95th percentile of the computed values

RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.J.7. Summary computation of CCME WQI in Manila Bay (2011-2025).

2011											
Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	9	6	1	8	Fail						
Fecal Coliform	27	100	24	3	Fail						
Total Coliform	27	1000	22	5	Fail	100	76	10	91	10	POOR
Nitrate	0	10	0	0	Fail						
Phosphate	0	0.2	0	0	Fail						
TSS	8	80	7	1	Fail						
2012											
Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	52	6	17	35	Fail						
Fecal Coliform	52	100	46	6	Fail	100	62	42	98	12	POOR

Total Coliform	52	1000	33	19	Fail
Nitrate	0	10	0	0	Fail
Phosphate	0	0.2	0	0	Fail
TSS	26	80	16	10	Fail

2013

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	66	6	29	37	Fail						
Fecal Coliform	65	100	61	4	Fail						
Total Coliform	50	1000	32	18	Fail	100	63	190	99	11	POOR
Nitrate	0	10	0	0	Fail						
Phosphate	20	0.2	20	0	Fail						
TSS	51	80	17	34	Fail						

2014

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	62	6	29	33	Fail						
Fecal Coliform	60	100	52	8	Fail						
Total Coliform	52	1000	30	22	Fail	83	55	160	99	19	POOR
Nitrate	15	10	0	15	Pass						
Phosphate	20	0.2	20	0	Fail						
TSS	36	80	4	32	Fail						

2015

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	63	6	38	25	Fail						
Fecal Coliform	63	100	61	2	Fail						
Total Coliform	43	1000	28	15	Fail	67	64	16,000	100	21	POOR
Nitrate	20	10	0	20	Pass						
Phosphate	20	0.2	20	0	Fail						
TSS	21	80	0	21	Pass						

2016

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	65	6	38	27	Fail						
Fecal Coliform	72	100	64	8	Fail						
Total Coliform	48	1000	35	13	Fail	83	60	120,000	100	17	POOR
Nitrate	28	10	0	28	Pass						
Phosphate	28	0.2	20	8	Fail						
TSS	28	80	4	24	Fail						

2017

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	66	6	36	30	Fail						
Fecal Coliform	68	100	60	8	Fail						
Total Coliform	1	1000	0	1	Pass	67	52	1,000,000	100	24	POOR
Nitrate	36	10	0	36	Pass						
Phosphate	36	0.2	5	31	Fail						
TSS	68	80	41	27	Fail						
2018											
Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	65	6	25	40	Fail						
Fecal Coliform	67	100	58	9	Fail						
Total Coliform	0	1000	0	0	Fail	83	46	1,900,000	100	20	POOR
Nitrate	36	10	0	36	Pass						
Phosphate	60	0.2	22	38	Fail						
TSS	68	80	32	36	Fail						
2019											
Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	108	6	60	48	Fail						
Fecal Coliform	124	100	110	14	Fail						
Total Coliform	60	1000	48	12	Fail	83	53	790,000,000	100	19	POOR
Nitrate	96	10	0	96	Pass						
Phosphate	108	0.2	30	78	Fail						
TSS	105	80	69	36	Fail						
2020											
Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	70	6	41	29	Fail						
Fecal Coliform	121	100	89	32	Fail						
Total Coliform	24	1000	6	18	Fail	83	50	1,800	100	19	POOR
Nitrate	67	10	0	67	Pass						
Phosphate	67	0.2	21	46	Fail						
TSS	74	80	55	19	Fail						
2021											
Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	106	6	74	32	Fail						
Fecal Coliform	151	100	146	5	Fail	83	62	980	100	17	POOR

Total	58	1000	46	12	Fail
Coliform					
Nitrate	106	10	0	106	Pass
Phosphate	106	0.2	38	68	Fail
TSS	106	80	86	20	Fail

2022

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	105	6	60	45	Fail						
Fecal Coliform	131	100	122	9	Fail						
Total Coliform	12	1000	12	0	Fail	83	50	120	99	20	POOR
Nitrate	108	10	0	108	Pass						
Phosphate	108	0.2	22	86	Fail						
TSS	91	80	62	29	Fail						

2023

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	115	6	66	49	Fail						
Fecal Coliform	159	100	136	23	Fail						
Total Coliform	60	1000	19	41	Fail	100	49	2,100	100	14	POOR
Nitrate	115	10	7	108	Fail						
Phosphate	115	0.2	24	91	Fail						
TSS	115	80	80	35	Fail						

2024

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	59	6	38	21	Fail						
Fecal Coliform	113	100	102	11	Fail						
Total Coliform	12	1000	12	0	Fail	83	60	240	100	17	POOR
Nitrate	59	10	0	59	Pass						
Phosphate	59	0.2	38	21	Fail						
TSS	59	80	26	33	Fail						

2025

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	53	6	42	11	Fail						
Fecal Coliform	65	100	37	28	Fail						
Total Coliform	30	1000	4	26	Fail	83	40	6.3	86	27	POOR
Nitrate	58	10	0	58	Pass						
Phosphate	54	0.2	10	44	Fail						
TSS	54	80	35	19	Fail						

Notes: *Class SB

DO, Nitrate and TSS follows the DENR Administrative Order 2016-08

Phosphate and Fecal Coliform DENR Administrative Order 2021-19

Total Coliform follows the DENR Administrative Order No. 34 s. 1990

n = number of data points

F1 = represents the percent of failed parameters that do not meet the guidelines at least once

F2 represents the percentage of individual tests that do not meet guidelines

nse = collective amount by which individual tests are out of compliance

F3 = represents the amount by which failed test values do not meet their guidelines

Status, Trends, and Management of Coastal Ecosystems of the Philippine Waters in the South China Sea-Large Marine Ecosystem (SCS-LME)

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Abstract

This report presents the current status of mangrove, wetland, coral reef, and seagrass ecosystems in the Philippine waters of the South China Sea Large Marine Ecosystem (SCS-LME). Data used were derived from published articles and other related available references. The gathered biodiversity, natural and human-induced threats, and socioeconomic valuation studies were analyzed to generate the risk indices from the identified threats to the ecosystems. The estimated average mangrove cover in this region is 35,553 ha, representing 14% of the entire Philippine mangrove forests. Of these provinces, the western seaboard of Palawan has the highest relative percent mangrove cover (76.5%) and the greatest species diversity (30 species). Mangrove cover had increased, particularly in 2020, resulting in an overall increase of 5,667 ha from 2000 to 2023. The average live coral cover in the region ranges from 24 to 26%, placing it in the fair condition category. Palawan has the largest reef area, comprising around 80% (325,770 ha), where the Kalayaan Island Group (KIG) alone accounts for roughly 320,000 ha of the Palawan reefs. Higher coral covers were located between Palawan and Occidental Mindoro while higher fish biomass, abundance, and diversity were also concentrated between Occidental Mindoro and the Calamianes Group of Islands in Palawan, including the KIG. The current estimated seagrass cover in the SCS-LME is at 12,685 km², or 1,268,500 ha. This reflects a 10,560 km² (1,056,000 ha) decrease in seagrass cover in the region from 2008 to 2020, or an overall decline of 54%. The coastal wetlands, Malampaya Sound Protected Landscape and Seascape in Palawan, the Las Piñas Parañaque Wetland Park, and Tanza Marine Tree Parks are among the significant biodiversity areas in the region. Data analysis had indicated the direct link of natural and human-induced threats to the deteriorating patterns of mangrove, coral, and seagrass ecosystems. Socioeconomic analysis identifies Palawan, Batangas, and Pangasinan as priority conservation areas where high biodiversity value coincides with intense human reliance and high ecological risks. Economic valuation underscores urgency: a 1% decline in coral reefs, mangroves, or seagrasses could result in millions of US dollars in annual losses, threatening fisheries, coastal protection, and tourism. Key challenges include incomplete and fragmented datasets, over-reliance on remote sensing without adequate ground-truthing, fluctuating mangrove cover, inequitable conservation outcomes across provinces, and limited institutional coordination. The findings stress the need for standardized monitoring, expanded and connected MPAs, stronger legal and institutional frameworks, climate-adaptive ecosystem management, and enhanced community stewardship and transboundary cooperation.

Keywords: Assessment, monitoring, risks, threats, valuation

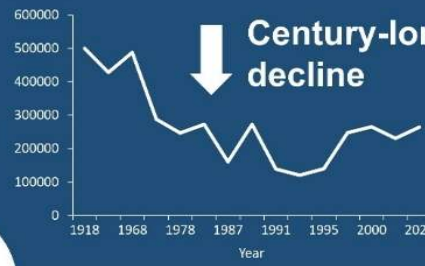
STATUS, TRENDS, AND MANAGEMENT OF COASTAL ECOSYSTEMS IN THE PHILIPPINES WATERS OF THE SOUTH CHINA SEA LARGE MARINE ECOSYSTEM (SCS-LME)






MANGROVES

Century-long decline




Palawan = Stronghold
76% of cover in SCS-LME
+ high diversity (30 spp)



SEAGRASS

30–50% decline in cover
+ biodiversity loss

Critical nursery habitat





CORAL REEFS

24–26% Live Cover
FAIR condition

Declining trend
= Fishing & Tourism

291 MPAs within SCS-LME
= 16% of total nationwide

MPAs importance in reef recovery amidst stress:
= improved coral cover and fish biomass within MPAs

CHALLENGES AND RECOMMENDATIONS



- Limited data and accessibility
- Limited institutional coordination
- Fragmented efforts in monitoring and conservation



- Expand and connect MPAs
- Enhance enforcement
- Enhance community stewardship and transboundary cooperation

4. Ecosystems

The Strategic Action Programme for the South China Sea (SCS-SAP) was jointly developed by seven participating countries bordering the South China Sea (SCS): Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam. The SCS-SAP provides a cooperative regional framework to address the degradation and loss of coastal and marine ecosystems through the development of a Transboundary Diagnostic Analysis (TDA), which identifies priority environmental issues, their underlying societal and economic root causes, and the transboundary impacts affecting the SCS region. The initial TDA highlighted that rapid economic growth, coastal urbanization, and population expansion in the SCS coastal zone—particularly during the period 1975–1995—were primary drivers of ecosystem degradation and resource depletion (UNEP, 2008).

Among the ecosystems identified as requiring strategic and priority actions under the SCS-SAP are mangroves, wetlands, coral reefs, and seagrass meadows. The regional assessment documented rapid and significant declines in the extent and condition of mangroves, coral reefs, and seagrass habitats across the SCS, driven by a combination of anthropogenic pressures—such as overfishing, destructive fishing practices, coastal development, pollution, and sedimentation—and natural stressors, including climate variability and extreme events. Corresponding management responses and regional targets were proposed to guide SCS-SAP implementation and support ecosystem recovery and sustainable use (UNEP, 2008).

This report contributes updated national-level information to the regional TDA-SAP process by synthesizing available data on coastal and marine ecosystems in the Philippine waters of the South China Sea Large Marine Ecosystem (SCS-LME) from 2000 onwards. It presents the current status and recent trends of mangroves, coral reefs, and seagrass ecosystems in the Philippines, with a particular focus on spatial patterns, observed changes in ecosystem condition, and key anthropogenic pressures influencing ecosystem health. By providing updated and site-specific evidence, this assessment aims to strengthen the Philippine input to the regional TDA, support improved ranking of ecosystem threats, and inform priority actions under the SCS-SAP framework.

4.1 Key Findings

- **Ecosystem Decline with Localized Gains:** Across mangroves, coral reefs, seagrasses, and wetlands in the SCS-LME, long-term trends show overall decline in extent and health, yet localized improvements (e.g., Palawan MPAs, seagrass recovery in some provinces) demonstrate that management interventions can be effective when consistently applied.
- **Palawan as the Stronghold:** Palawan emerges as the most ecologically significant province, hosting the largest and most stable mangrove forests, extensive coral reefs, and the highest seagrass cover, while also supporting the richest biodiversity, including many endangered and endemic species.
- **Vulnerability to Climate and Anthropogenic Pressures:** Coral reefs, particularly in the Kalayaan Island Group, remain in poor condition (average coral cover ~16%) and are highly exposed to climate pressures (typhoons, warming seas). Coastal development, destructive fishing, and weak enforcement amplify these risks.
- **Critical Biodiversity Hotspots Under Stress:** Key Biodiversity Areas (KBAs) such as Apo Reef, Malampaya Sound in Palawan, the Las Piñas-Parañaque Wetland Park and Tanza Marine Tree Park in National Capital Region (NCR) harbor high ecosystem diversity and connectivity, but are increasingly threatened by habitat loss, poaching, and unregulated tourism, underscoring the need for integrated protection.
- **Economic Losses from Ecosystem Degradation:** Even small declines in reef, mangrove, seagrass, and wetland extent translate to millions of dollars in lost ecosystem services annually, with coral reefs carrying the greatest potential economic losses due to their role in fisheries, tourism, and coastal protection.
- **Species of Global Concern at Risk:** The SCS-LME remains a refuge for critically endangered and vulnerable species (e.g., hawksbill turtles, dugongs, napoleon wrasse, giant clams), yet many populations

face steep declines from overfishing, habitat degradation, and marine debris, pointing to urgent conservation needs.

- **Spatially Uneven Data and Management Gaps:** While Palawan and selected MPAs benefit from robust monitoring, other provinces lack consistent, site-level data on habitat condition, biodiversity, and climate vulnerability, limiting the reliability of national-scale assessments and impeding evidence-based decision-making.
- **Socioeconomic Dependence vs. Risk:** Provinces like Pangasinan and Batangas rank high in both socioeconomic reliance and ecological risk, highlighting how local communities are directly vulnerable to ecosystem degradation. By contrast, low-priority provinces such as Batanes and Ilocos Norte currently show lower biodiversity and human pressure, though monitoring remains necessary to detect emerging threats.
- **Need for Regional and Transboundary Action:** Ecological connectivity (e.g., larval dispersal between Kalayaan and Palawan) highlights that ecosystems and species span boundaries. Strengthened transboundary cooperation under frameworks like SCS-SAP is critical to sustain ecological resilience and biodiversity in the wider region.

4.2 Current Status by Ecosystem and by Indicator Group

4.2.1 Mangroves and Wetlands

4.2.1.1 Mangroves

4.2.1.1.1 Mangroves Species Diversity

The most recent list of mangroves in the Philippines is provided by Buot Jr. et al. (2022) (see ANNEX A). This includes 39 species with conservation status per IUCN Red List of Threaten Species (Table 4.1). The listed near-threatened species, the *Ceriops decandra* (Griff.) W. Theob. is now named *Ceriops zippeliana* (Sheue et al., 2010). Aside from the endangered *Camptostemon philippinense* (S.Vidal) Becc., two other species, the *Pemphis acidula* J.R. Forst. & G. Forst. and *Kandelia candel* (L.) Druce are categorized as threaten species in the Philippines per Department of Environment and Natural Resources Administrative Order or DAO 2017-11 also known as the Philippine Red List. These species are highly exploited and have very limited range of distribution. The *Kandelia candel* (L.) Druce for instance can be found only in Baler Aurora in the central easternmost coast of Luzon Island (Malabrigo et al., 2021).

The earlier report of Primavera (2000) on mangrove species from various sources (1920-1986) indicated at least eight species missing in the 2004-2007 listing or became locally extinct or extirpated (Table 4.2). This includes the IUCN-critically endangered species, the *Bruguiera hainesii* C.G.Rogers. Both information from IUCN and Philippines Red Lists of threaten species are important to policy-makers, environmental managers, and the communities.

Table 4.1. The IUCN and the Philippines Red Listed mangrove species (Buot Jr. et al., 2022).

Family	Species	DAO 2017-11	IUCN
Lythraceae	<i>Sonneratia ovata</i> Backer		NT
	<i>Pemphis acidula</i> J.R. Forst. & G. Forst.	EN	
Malvaceae	<i>Camptostemon philippinense</i> (S.Vidal) Becc.	EN	EN
	<i>Brownlowia tersa</i> (L.) Kosterm.		NT
Primulaceae	<i>Aegiceras floridum</i> Roem. & Schult.		NT
Rhizophoraceae	<i>Bruguiera hainesii</i> C.G.Rogers		CR
	<i>Ceriops decandra</i> (Griff.) W.Theob.		NT

Legend: CR= Critically Endangered; EN= Endangered; NT= Near-Threaten

Table 4.2. The summary list of locally extinct mangrove species in the Philippines (Primavera, 2000).

Family	Locally Extinct Species (Extirpated)
Bombacaceae	<i>Camptostemon schultzei</i>
Sonneratiaceae	<i>Sonneratia gulngai</i>
	<i>Sonneratia lanceolata</i>
	<i>Xylocarpus mekongensis</i>
Meliaceae	<i>Aegialitis annulata</i>
Plumbaginaceae	<i>Bruguiera exaristata</i>
Rhizophoraceae	<i>Bruguiera hainesii</i>
	<i>Rhizophora lamarckii</i>

Among provinces in the Philippines waters of SCS-LME, the western seaboard of Palawan hosts the most diverse mangrove forests, with 30 species, dominated by *Rhizophora* and *Sonneratia* species. This is followed by Pangasinan (25 spp.), Zambales (21 spp.), and Batangas (20 spp.) (Salmo III et al., 2014; Ting et al., 2014; (Figure 4.1). However, information on mangrove species diversity over time in these provinces remains limited. Existing data, derived from sporadic studies fail to capture temporal trends in species diversity. Systematic and site-specific monitoring are imperative to generate such information.

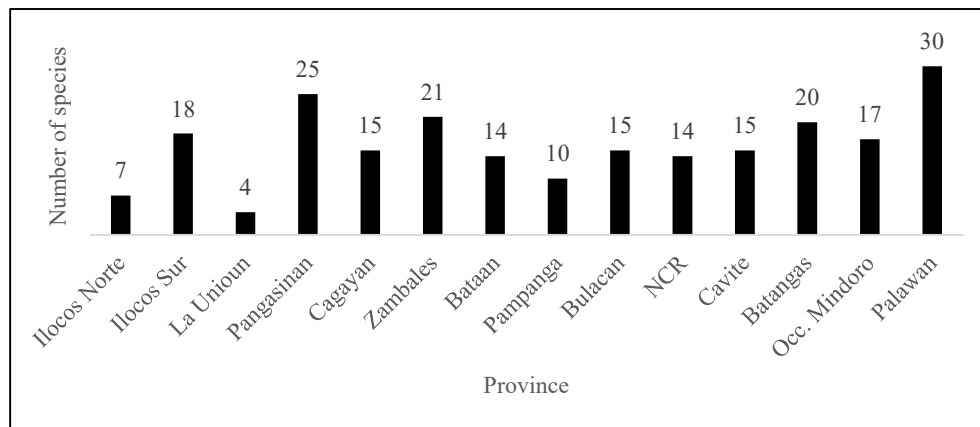


Figure 4.1. The number of mangrove species in provinces bordering the Philippine waters within the SCS-LME.

4.2.1.1.2 Threats to Mangrove Forests

The human-induced and natural threats to mangroves and wetlands across provinces in the Philippine waters with the SCS-LME are presented in Table 4.3. The information was derived from the latest available published articles. Mangrove forests and coastal wetlands across the assessed provinces are experiencing compounding pressures from climate-related hazards and anthropogenic activities, resulting in varying but often high levels of ecosystem vulnerability. Typhoons, storm surges, flooding, and sea-level rise are pervasive natural stressors across all provinces, establishing a baseline of climate risk. However, human-induced pressures, particularly land conversion, aquaculture expansion, coastal reclamation, and pollution, are the dominant drivers of degradation, especially in Manila Bay provinces (NCR, Cavite, Bulacan, and Bataan) where cumulative impacts are most severe. Cagayan and Pangasinan also exhibit high combined threat levels due to the interaction of intense natural hazards with extensive aquaculture development and watershed-derived pollution. In contrast, the Ilocos provinces and La Union are primarily influenced by climate-driven risks with moderate development pressures, while Occidental Mindoro and the west coast of Palawan retain relatively intact mangrove systems but face emerging risks from development and increasing climate

variability. The occurrence of these threats across provinces in the Philippine waters with the SCS-LME is provided in Annex 4.A.

Table 4.3. List of human-induced and natural threats to mangroves and wetlands across provinces in the Philippines waters within the SCS-LME (Hermes, 2024; CCC 2024; Baloloy et al., 2023; WB, 2017; Garcia et al., 2013).

Province	Natural threats	Human-induced threats
Ilocos Norte	Storms/typhoons, storm surge, coastal hazards affecting mangroves	Land-use conversion (coastal development, aquaculture/ponds), settlement pressure, pollution/plastic and waste threats
Ilocos Sur	Coastal erosion, storm / climate-driven hazards to mangroves	Coastal development / land conversion; aquaculture/fishpond conversion; human settlement expansion
La Union	Coastal hazard exposure (sea-level rise, storms, inundation risk, erosion)	Conversion/clearing for agriculture or settlement; degradation from land-use change and resource extraction
Cagayan	Typhoons, coastal hazard risk, changes in sediment/river-mouth dynamics threatening mangrove regeneration	Conversion for aquaculture/ponds, human settlement and land-use change, over-harvesting for wood/charcoal
Pangasinan	Coastal flooding, storm surge, erosion, sea-level / climate-driven stress on coasts	Large-scale conversion to fishponds/aquaculture; loss of mangrove area; pollution/runoff and degradation from land-use change
Cavite	Coastal hazard risk (storms, surge, sea-level rise), exposure due to bay/shoreline geography	Land reclamation, coastal development, conversion to urban/industrial uses, habitat destruction & pollution from coastal infrastructure
Batangas	Coastal erosion/shoreline changes, storm / sea-level rise risk on exposed bays and coasts	Coastal development (tourism, ports, infrastructure), conversion for settlements or aquaculture, pollution risks from industrial and urban runoff / coastal activities
NCR (Metro Manila/Manila Bay)	Coastal squeeze: hardened shorelines + sea-level rise/ storm surge increase inundation & flood risk; reduced natural buffering capacity	Massive land reclamation, urban/industrial coastal development, pollution, waste discharge, habitat loss from coastal infrastructure
Bulacan	Flooding, storm surge risk in low-lying coastal/wetland zones; salinity and erosion risk in tidal flats	Reclamation / coastal land conversion (Manila Bay zone), urban expansion, altered hydrology, pollution from upstream runoff
Bataan	Coastal hazard exposure — storms, coastal inundation and erosion risks on bay/coast wetlands	Historical conversion to aquaculture/fishponds or land-use change; industrial/urban coastal development and pollution pressures from Manila Bay ecosystem change
Occidental Mindoro	Coastal erosion, shoreline changes and climate-driven hazards (storm, sea-level changes) that affect mangrove stability	Conversion to aquaculture/ponds, clearing for settlements, deforestation for wood/charcoal, land-use change and general anthropogenic degradation
West coast of Palawan	Storm / typhoon damage, sea-level rise and coastal hazard exposure; natural shoreline dynamics risking mangrove stability	Clearing for aquaculture/ponds or fish-farms, coastal development (settlements, resource extraction such as wood/charcoal), pollution, land conversion and other human pressures despite protected-area status in parts

The national estimate of total mangrove forest cover in 1980, 1990, and 2000, as well as the corresponding percent rate of loss per year, were provided in the SCS-SAP Project (UNEP, 2008). From 2000 to 2020, the Philippines mangrove forest cover is illustrated in Figure. 4.1. There was a decreased of approximately 63,429 ha in mangrove cover from 2000-2010 while an increase of 34,221 ha from 2010-2020 or a net decreased of 29,208 ha from 2000-2020 (Baloloy et al., 2023).

There are 12 provinces bordering the Philippine waters within the South China Sea- Large Marine Ecosystem (SCS-LME). These include the Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Batanes, Cagayan, Bataan, Bulacan, Cavite, Batangas, Occidental Mindoro, and western seaboard of Palawan. The estimated average mangrove cover in this region is 35,553 ha, representing 14% of the entire Philippine mangrove forests. Of these provinces, the western

seaboard of Palawan has the highest relative percent mangrove cover (76.5%) followed by Cagayan (13.5%). The remaining 10% is shared by other provinces except the Batanes in Region 2, which is devoid of mangroves (Long et al., 2014; Zablan et al., 2022).

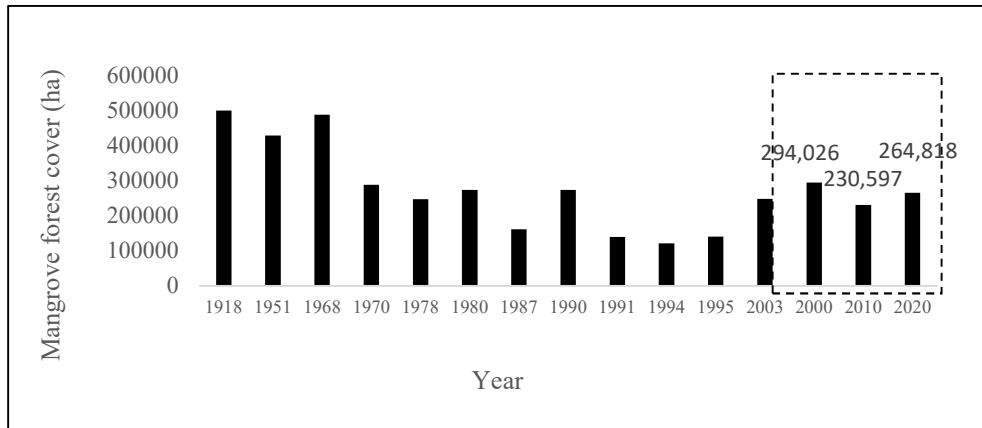
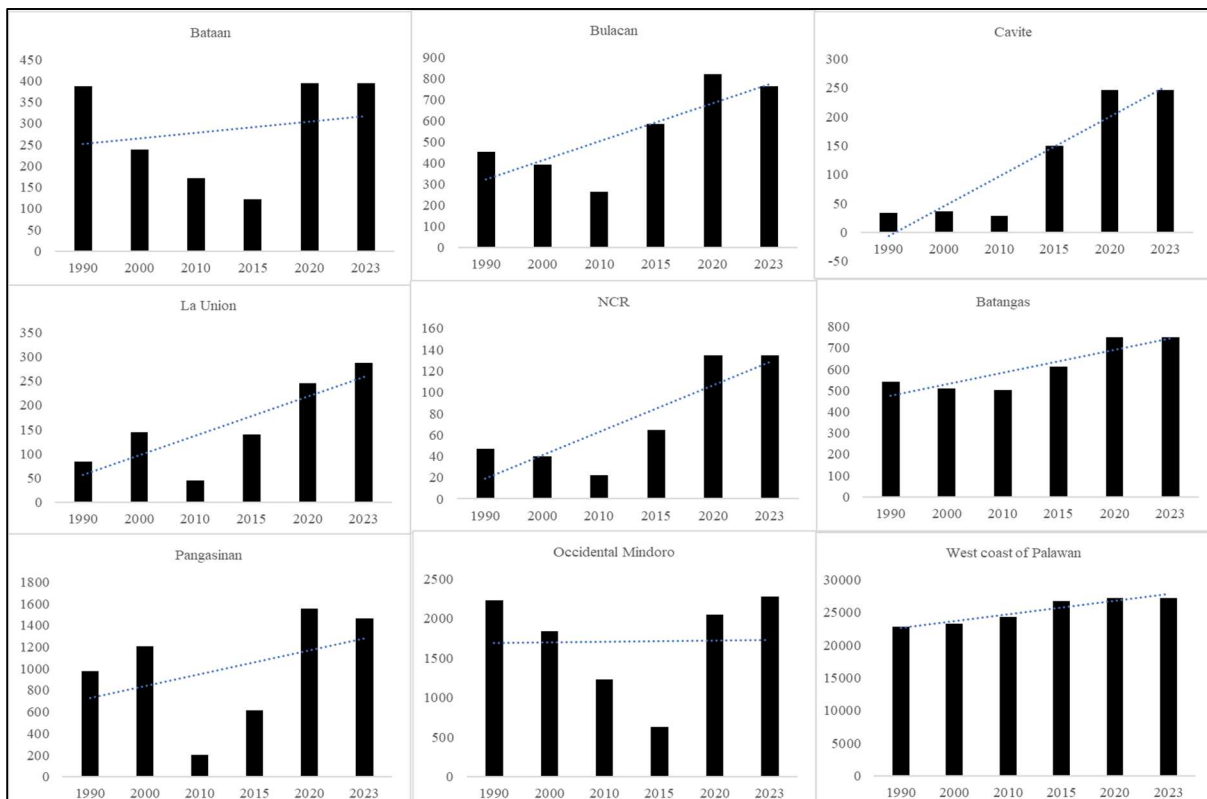


Figure 4.2. The Philippines mangrove forest cover from 1918 to 2020 with emphasis on the recent data, years 2000-2020.

The trends of mangrove cover from 1990 to 2023 among provinces in the region are presented in Figure 4.3. At least nine provinces, the Bataan, Bulacan, Cavite, La Union, NCR, Batangas, Pangasinan, Occidental Mindoro, and the western seaboard of Palawan have increasing mangrove cover. The Cagayan, Pampanga, and Zambales have minimal change over time while Ilocos Sur and Ilocos Norte have decreasing trends. The change of mangrove covers in the region between 2000-2023 is shown in Figure. 4.3. Mangrove cover had increased, particularly in 2020, resulting to an overall increase of 5, 667 ha from 2000-2023 (Long et al., 2014; Salmo III et al., 2015; Ting et al., 2015; PSA CPES 2010-2019; 2012-2022;2014-2023; Hawort et al., 2024).



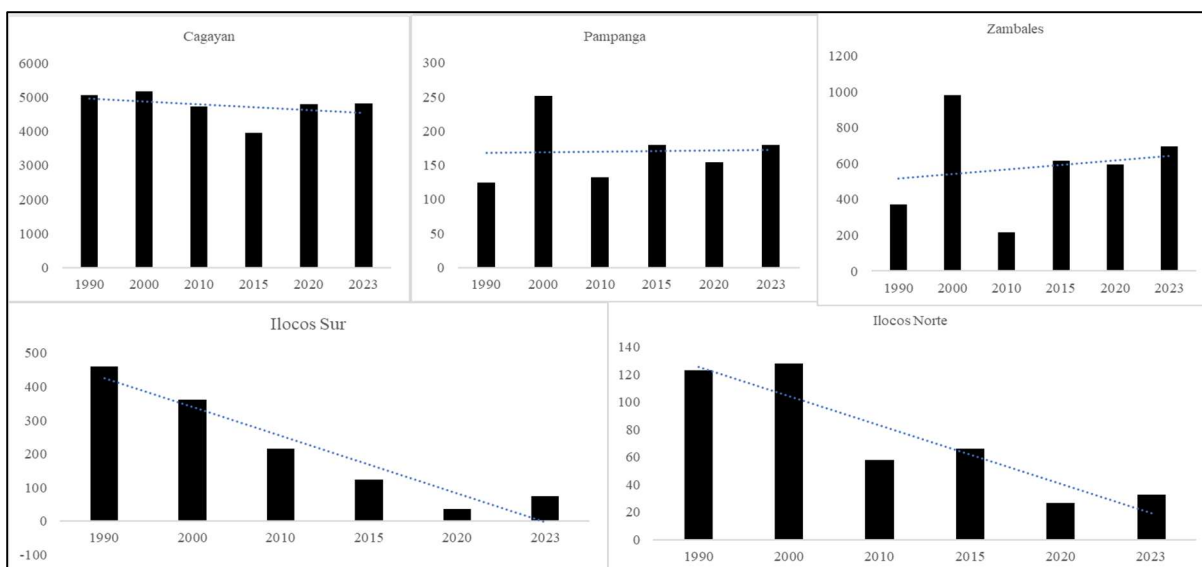


Figure 4.3. The trend of mangrove forest cover in provinces bordering the Philippine waters of the SCS-LME from 1990-2023.

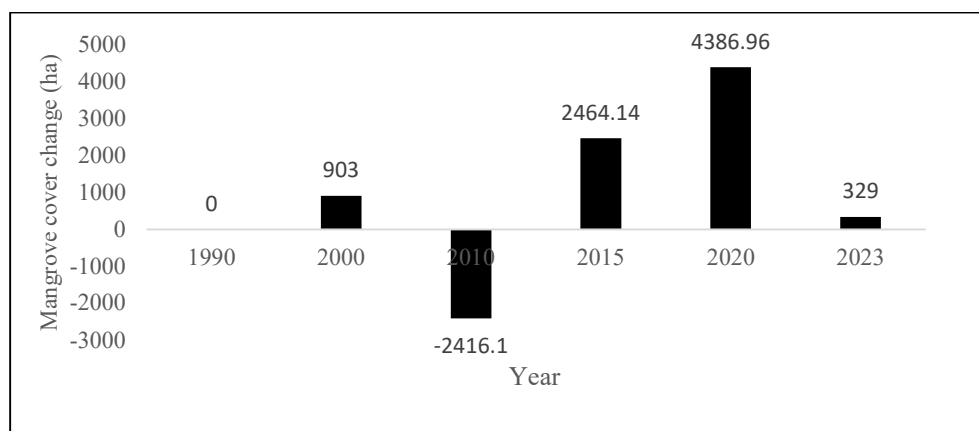


Figure 4.4. Mangrove cover change in the Philippine waters of SCS-LME from 2000-2023.

4.2.2 Coral Reefs and Seagrasses

4.2.2.1 Coral Reefs

4.2.2.1.1 Coral Reef Area

The Philippine waters in the SCS-LME has an estimated coral reef area ranging from 3,712.1 km² (371,210 ha) to 4,051.6 km² (405,161 ha), representing approximately 30% of the Philippines' total reef area (Aliño et al., 2019). The total reef area of each province bordering the SCS-LME is shown in Figure 4.5. The average live coral cover across the Philippine waters in the SCS-LME range from 24–26%, placing it in the fair condition category (Licuanan et al., 2019; Arceo et al., 2024). Palawan has the largest reef area comprising around 80% (325,770 ha) where the Kalayaan Island Group (KIG) alone accounts for roughly 320,000 ha of the reefs of Palawan, but with a much lower average coral cover of 16% (Arceo et al., 2024). As shown in Figure 4.6, of the 13 sites across the provinces in the SCS-LME, 40% were in poor condition (LHC cover: 0-22%) and 40% were in fair condition (LHC cover: 22-33%). Only 2 sites (13.3%) were in good condition (LHC cover: 33-44%) and only 1 province with excellent condition (LHC: > 44%). Generally higher coral covers were located between Palawan and Occidental Mindoro with highest observed in Sablayan, Mindoro. For fish parameters, higher fish biomass, abundance, and diversity were also

concentrated between Occidental Mindoro and Calamianes Group of Islands in Palawan. Interestingly, despite low coral cover, fish biomass was also high in KIG (Figure 4.6).

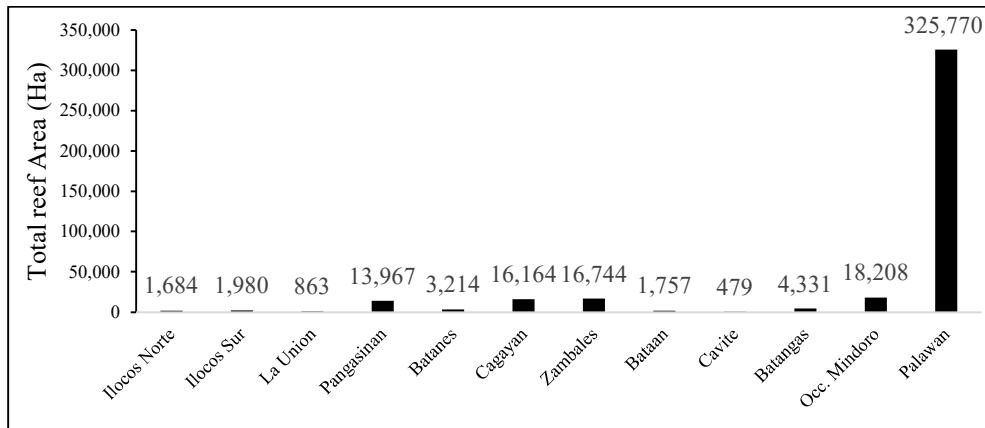


Figure 4.5. Estimates of Coral Reef Area in the provinces bordering the South China Sea-Large Marine Ecosystems (Source: PSA CPES 2014-2023; Arceo et al., 2024).

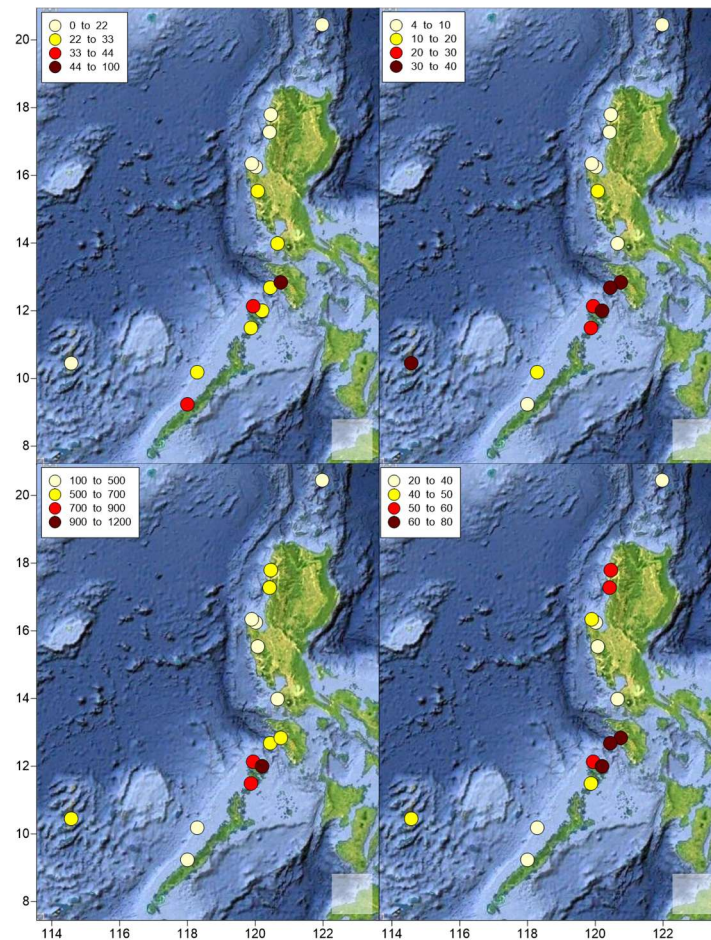


Figure 4.6. Reef parameters: a) Live hard coral cover (%), b) fish biomass (mt/km²), c) fish abundance (indl/500m²), and d) fish diversity (no. of species/500m²) in different reef sites in the WPS. Data gathered from Arceo et al., 2024.

4.2.2.1.2 Coral Cover

The establishment of Marine Protected Areas (MPAs) has long been recognized as an essential conservation strategy and has gained significant increase since the 1990s (Campos & Aliño, 2008). There are approximately 1,800 MPAs across the Philippines (Cabral et al., 2014), with about 291 of these are located within the Philippine waters of the South China Sea Large Marine Ecosystem (SCS-LME) (Arceo et al., 2024). At the local scale, particularly within well-managed MPAs, some sites have demonstrated encouraging trends in reef health (Figure 4.7). Long-term surveys show positive changes in live coral cover in three MPAs in Calamianes, Palawan: Bugor (Culion) improved from 41.4% in 2006 to 52% in 2022; Concepcion (Busuanga) increased from 60.4% to 65.2% over the same period; and Siete Pecados (Coron) recorded a slight increase from 52% in 2013 to 53.1% in 2022 (Campos et al., 2022). These gains suggest that effective management and protection can promote localized reef recovery. This result is consistent with that obtained in the municipality of Taytay, though with considerable variation between sites (0–7.3% per year), corals showed an average annual recovery rate of 2.8 percent over the nine years (Abesamis et al., 2023).

By contrast, reef sites outside MPAs or exposed to heavy fishing and tourism pressures have shown marked declines. In Diwaran Island (Coron) and Denicolan (Busuanga), coral covers dropped from above 50% in 2006 (PCSD, 2006) to less than 30% by 2016 (DENR, 2017). Similar trends were observed in heavily visited sites such as Dynamite Point (Culion) and Calambuyan (Busuanga). Although survey methods may differ (e.g., transect placement, use of LIT vs. photo transects, depth), these results point to consistent signs of localized reef degradation.

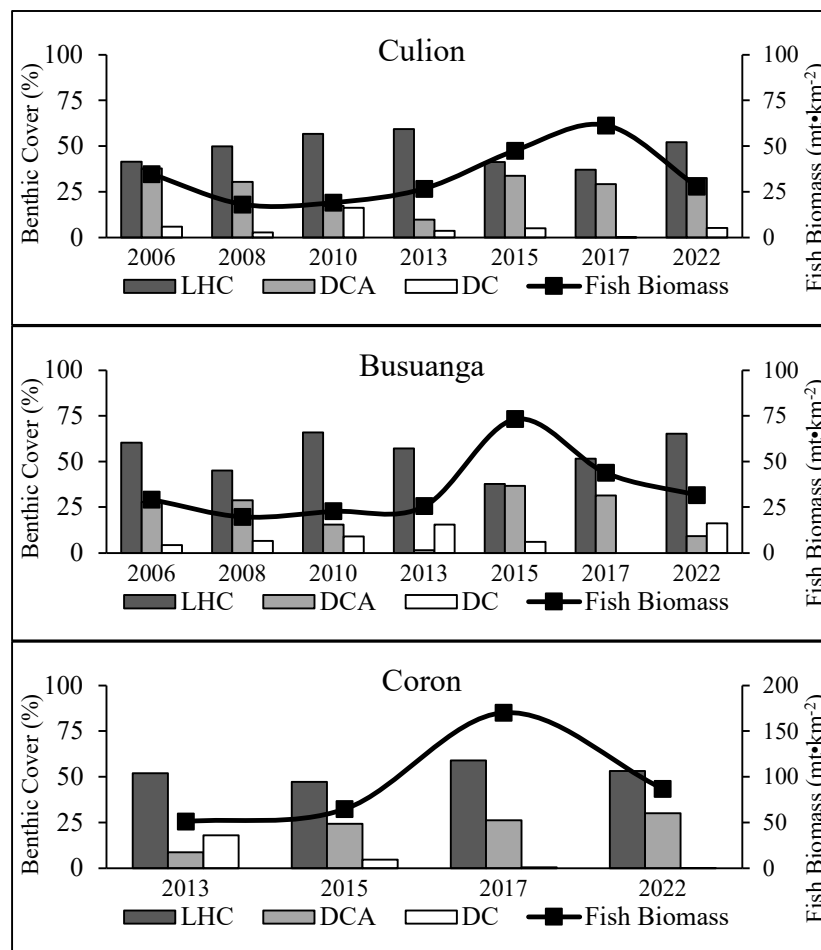


Figure 4.7. Reef parameters observed from biennial surveys in three Marine Protected Areas (MPAs) in the Calamianes: Busuanga and Culion (2006-2022), and Coron (2013-2022). Data collected by Campos et al., 2022

On the larger scale, the relatively low coral cover in SCS-LME, particularly in the KIG, suggests limited ecological recovery and continued exposure to stressors such as climate change, overfishing, and destructive practices. Historical records show that Pag-asa Island experienced an average of one typhoon per year in the 1980s, rising to two per year in the 2000s (Villanoy & Yñiguez, 2024), adding climate-related pressures. Weak enforcement particularly in remote and offshore reefs remains a major barrier to conservation. Overall, a comparison between 2003–2007 and 2015–2017 (Fig. 4.8) shows a decline of live hard coral cover (LHC) and fish biomass across multiple reef sites in the waters off SCS-LME (SAP-SCS, 2008; CRINP, 2008; Licuanan et al., 2019; Arceo et al., 2024). This declining trend of coral cover is consistent with that observed in several reef sites around Palawan from 2012-2023 (Haworth et al., 2023).

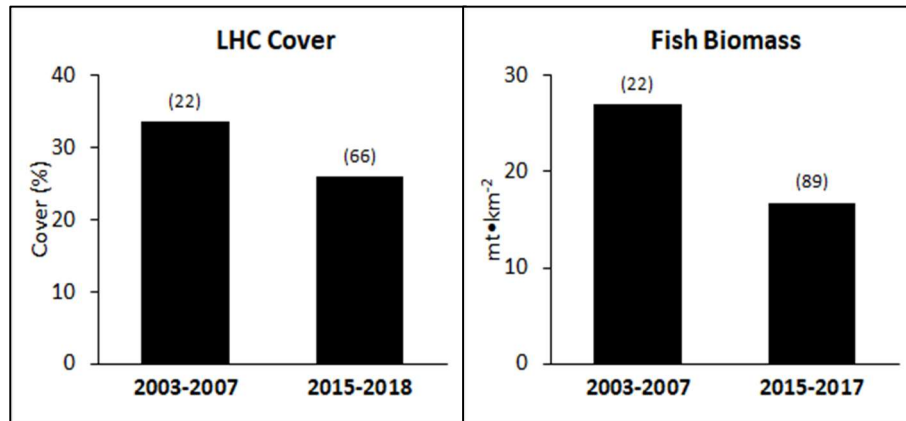


Figure 4.8. Live hard coral cover (left) and fish biomass (right) recorded between 2003-2007 and 2015-2018 across selected sites in the WPS. Data gathered from SAP-SCS, 2008; CRINP, 2008; Licuanan et al., 2019; Arceo et al., 2024

4.2.2.2 Seagrasses

4.2.2.2.1 Seagrasses Cover

From the 2008 TDA-SAP report, the seagrass meadow confined in the Philippine water within the SCS-LME was estimated at 23,245 km² (UNEP, 2008). In 2020, the country's seagrass cover of 14,923 km² was reported in the World Conservation Monitoring Center of the Global Distribution of Seagrasses-United Nations for the Environment and Programme (Fortes, 2021). Based on an approximate 85% representation of the SCS-LME seagrass cover compared to the entire cover in the Philippines (Fortes, 2018), the current estimated seagrass cover in the SCS-LME is at 12,685 km² or 1,268,500 ha. This reflects a 10,560 km² (1,056,000 ha) decrease in seagrass cover in the region from 2008-2020 or an overall decline of 54%.

Across provinces within the SCS-LME, the Pangasinan, particularly the Cape Bolinao holds the highest recorded seagrass cover followed by the western seaboard of Palawan and Occidental Mindoro. The seagrass cover value for these provinces was confined only to Ulugan Bay, Honda Bay, Bacuit Bay, Malampaya Sound, Busuanga, and Coron (for Palawan) and Puerto Galera (for Occidental Mindoro) (Figure 4.9). Time-series data reflecting the change in seagrass cover over time in these provinces is lacking. The only available data is from PCSD report, indicating the declining health condition of seagrasses in Palawan from 2004-2020 (Howart et al., 2024). Accordingly, the percentage of seagrass meadows in “excellent-good” conditions had decreased while those in “fair-poor” status had increased (Figure 4.10).

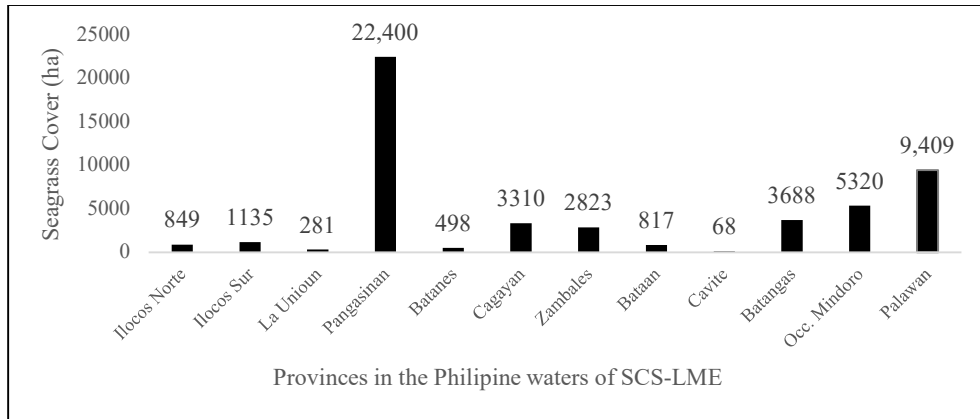


Figure 4.9 Seagrass cover in provinces bordering the Philippine waters of the SCS-LME.

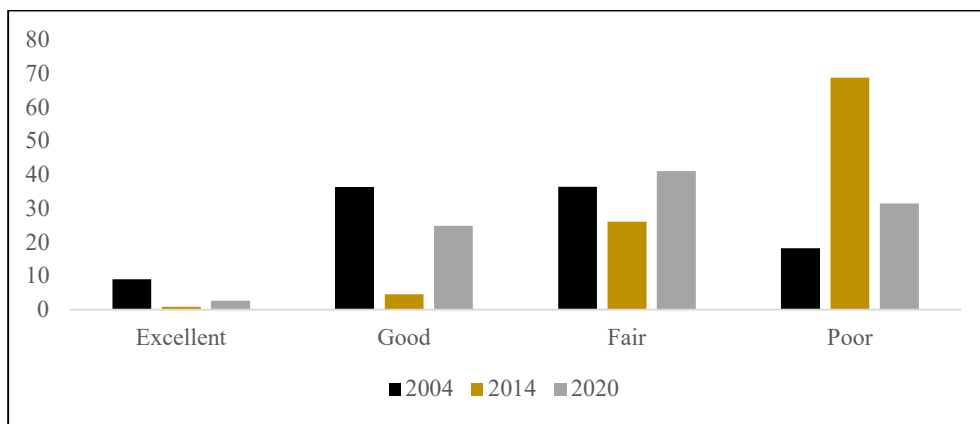


Figure 4.10. Status of seagrass meadows in Palawan from 2004-2020.

4.2.2.2.2 Seagrass Species Diversity

The country is home to 19 seagrass species (Fortes et al., 2018). From 2000 to date, only a few articles on seagrass biodiversity studies were published. The available data on species richness in provinces bordering the SCS-LME is presented in Fig. 4.11. At present only 13 seagrass species have been documented in the Philippines (see ANNEX C). The six other species, the *Halophila beccarii*, *Halophila decipiens*, *Halophila gaudichaudii*, *Halophila ovata*, *Halophila spinulosa*, and *Ruppia maritima* were unreported, and the species *Thalassodendron ciliatum* is becoming rare or having a very limited distribution. It was also reported that *H. beccarii* had faced local extinction decades ago (Fortes, 2021).

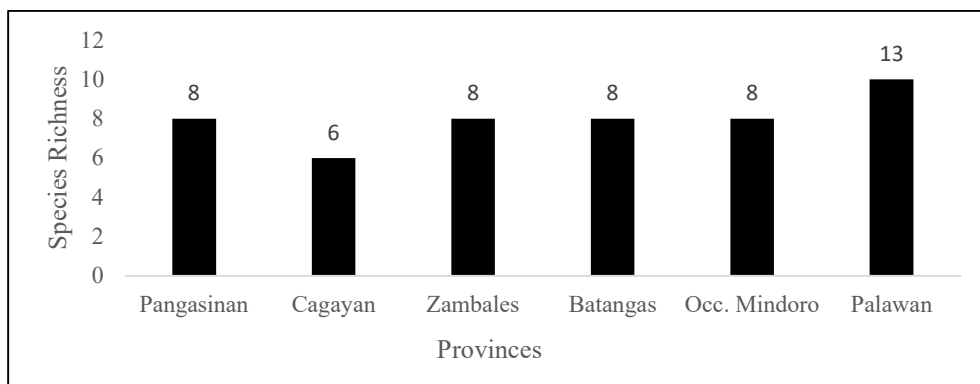


Figure 4.11. Seagrass species richness in some provinces bordering the Philippine waters in the SCS-LME.

4.2.2.2.3 Seagrass Threats

The decline in seagrass cover and diversity was attributed to increased nutrient loading and sedimentation that resulted from unsustainable coastal development, forest loss, aquaculture, and rising temperatures of shallow coastal waters (Fortes, 2021; Sudo et al., 2021). The country’s seagrass beds are prone to such disturbance, considering that only 9% of the total seagrass beds are within the Marine Protected Area or MPA and only 25.8% are covered within the Ecologically or Biologically Significant Marine Areas or EBSAs (Sudo et al., 2021). The detailed list of natural and human-induced threats with corresponding degree of severity of impact to seagrass meadows is presented in Table 4.4. According to Fortes (2021), these threats were the same since 1990’s and only the severity of impact had changed over time. The occurrence of these threats across provinces in the Philippine waters with the SCS-LME is provided in Annex 4.D.

Table 4.4. The list of human-induced and natural threats to seagrass meadows in the Philippines (Fortes, 2021)

Human-Induced Threats	Degree of Impact	Natural Threats	Degree of Impact
Habitat destruction	***	Red tides	*
Sewage pollution	***	Natural hazards (typhoons, storm surges)	*
Industrial pollution	***	Sea-level rise	*
Fisheries overexploitation	***	Sea surface temperature rise	*
Siltation / sedimentation	***	Natural sediment dynamics	*
Oil pollution	**		
Agricultural pollution	**		
Hazardous waste	*		
Coastal erosion	*		

Legend: *** Severe, ** Moderate, * Slight / Low

4.2.3 Biodiversity Hotspots and Sensitive Areas

4.2.3.1 Mangrove and Wetlands

The western seaboard of Palawan, covering the coastal municipalities of Balabac, Rizal, Quezon, Aborlan, Puerto Princesa City, San Vicente, Taytay, El Nido, Linapacan, Culion, Busuanga, and Coron, serves as a mangrove biodiversity hotspot of the Philippine waters within the SCS-LME because of its extensive forest cover, high species richness, and biogeographic significance. The coast contains approximately 41% of the total mangroves in the region. These forests exhibit high structural complexity and ecological integrity with positive cover changes of 3,078.65 ha between 2000-2010 and 2,233.36 ha in 2010-2020. The municipalities of Balabac and Taytay and the City of Puerto Princesa contributed a huge percentage to the overall mangrove cover in the island (Figure 4.12) (Zablan et al., 2022). Mangroves in Taytay, Palawan are concentrated in Taytay Bay and Malampaya Sound while in Puerto Princesa City, at Ulugan Bay. Using multi-date landsat satellite images combined with Markov chain model, the present and projected mangrove cover in these sites were determined and based from the predicted outcome, mangroves in Taytay Bay, Malampaya Sound, and Ulugan Bay are expected to increase in years 2030 and 2050, provided that threats are regulated and restoration initiatives will continue (Cayetano et al., 2023). The Calamianes Group of Islands, comprising of Culion, Busuanga, and Coron, in the northern-most part of Palawan is also a site-specific mangrove biodiversity hotspot within the province.

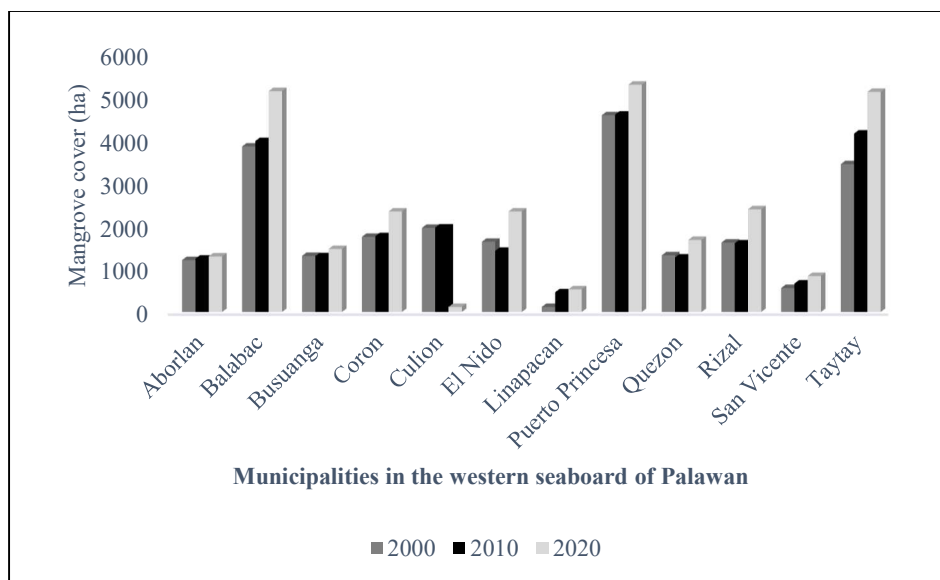


Figure 4.12. Mangrove cover in municipalities bordering the western seaboard of Palawan

Situated also in the west coast of Palawan are the four Protected Areas (PA) with extensive mangrove cover, the Calauit Island Game Preserve and Wildlife Sanctuary in Busuanga (PD No. 1578 s. 1976; El Nido Manage Reserve Protected Area in El Nido (Proclamation No. 32 s. 1998; Malampaya Sound Protected Landscape and Seascape (MSPLS) in Taytay (proclamation No. 342 s. 2000); and Puerto Princesa Subterranean River and Natural Park in Puerto Princesa City (Proclamation No. 212 s. 1999). The biodiversity profile of MSPLS is presented in Annex 4.C. of the report.

The mangrove forest in the NCR or Metro Manila is the most sensitive vegetation in region. The Las Piñas-Parañaque Wetland Park (LPPWP) and Tanza Marine Tree Park (TMTP) are significant mangrove areas within Manila Bay, with estimated cover of 20.73 ha and 30 ha, respectively. The LPPWP was proclaimed (Proclamation No. 1412, s. 2007) as critical habitat and ecotourism area on 22 April 2007. Years later, it was upgraded into a national protected area through the Expanded National Integrated Protected Areas System (ENIPAS) Act of 2018 and subsequently declared as a RAMSAR site. The LPPWP harbors 23 mangrove species and a number of bird species (ERDB, 2021). The TMTP was designated as a "marine tree park" through a Barangay Council Ordinance No. 4, s. 2011. It is home to 13 mangrove species, endangered and migratory birds (DENR-NCR, 2021) (see Annex 4.F).

Human-induced threats to mangrove forests in LPPWP and TMTP are the on-going reclamation projects; poor water quality attributed to wastes and pollutants from the inadequate management of wastes from domestic, commercial, and industrial activities and wastewater discharges from households, industries, and commercial and institutional establishments; and garbage deposition and pollution. Particularly, garbage from the communities in Canacao Bay, Bacoor Bay, Paranaque City and Las Piñas are directly dump into the rivers and gradually to the beaches of LPPWP (ERDB, 2021).

4.2.3.2 Corals and Seagrass

Connectivity studies have demonstrated that the Kalayaan Island Group, functions as both a larval source and sink, with currents dispersing coral and fish larvae toward Palawan and northern Sulu Sea ecosystems (Junio-Meñez et al., 2015; Dorman et al., 2016). This underscores the transboundary ecological role of the SCS-LME in sustaining regional biodiversity. Seasonal monsoon currents further reinforce this connectivity, facilitating recruitment across interconnected reef systems (Dorman et al., 2016). In addition, the Verde Island Passage is also a critical

biodiversity hotspot, known for harboring exceptionally high densities of fish eggs and serving as an important spawning and larval dispersal area (Campos et al., 2008).

The ecological sensitivity of the different provinces in SCS-LME is also influenced by climate exposure. According to the Philippine Climate-Ocean Typology (Aliño et al., 2019), areas within the SCS-LME are subject to significant sea surface temperature fluctuations, sea level rise, and monsoonal disturbances. Fig. 4.13a shows that western Luzon including Ilocos Sur, Pangasinan and Zambales, are exposed to several climate threats such as extreme heat, extreme rainfall, sea level rise, and monsoonal disturbance (Aliño et al., 2019). Storm frequency and fisher density are also relatively high in these areas including the KIG (Fig. 4.13b-c). These climate pressures compound the impacts of destructive fishing, coastal development, and pollution, increasing the vulnerability of reef ecosystems. El Niño events, for example, have been shown to disrupt larval connectivity across the Eastern Pacific barrier, potentially limiting recruitment success and reducing genetic flow between coral populations (Wood et al., 2016). Additionally, outbreaks of Crown-of-Thorns Starfish (*Acanthaster cf. solaris*), driven by elevated nutrient loads and high larval survival, pose a recurring threat to coral cover and reef structure. Genetic analyses confirm that populations of this coral predator are moderately connected across the SCS, including the Spratlys and Palawan (Chen et al., 2021), underscoring the need for transboundary outbreak management.

Palawan is the most notable hotspot of seagrass biodiversity in the region. Seagrasses serve as a vital ecological link between mangroves and coral reefs and offer vital habitat for fisheries and megafauna like the dugongs. The Occidental Mindoro and Batangas function as regional seagrass biodiversity hotspots. Occidental Mindoro supports large, relatively intact seagrass meadows along the Mindoro Strait, characterized by high species richness and important dugong feeding grounds, and retains comparatively higher ecological integrity. In contrast, Batangas, particularly within the Verde Island Passage, hosts diverse seagrass assemblages tightly connected to one of the world’s richest coral reef systems, but these ecosystems are increasingly constrained by intense coastal development, shipping, and tourism pressure. At a more localized scale, Cape Bolinao in Pangasinan stands out as a seagrass hotspot along the western Luzon coast. Although spatially limited, its seagrass beds exhibit relatively high species diversity and productivity and play an important role in supporting adjacent reef fisheries.

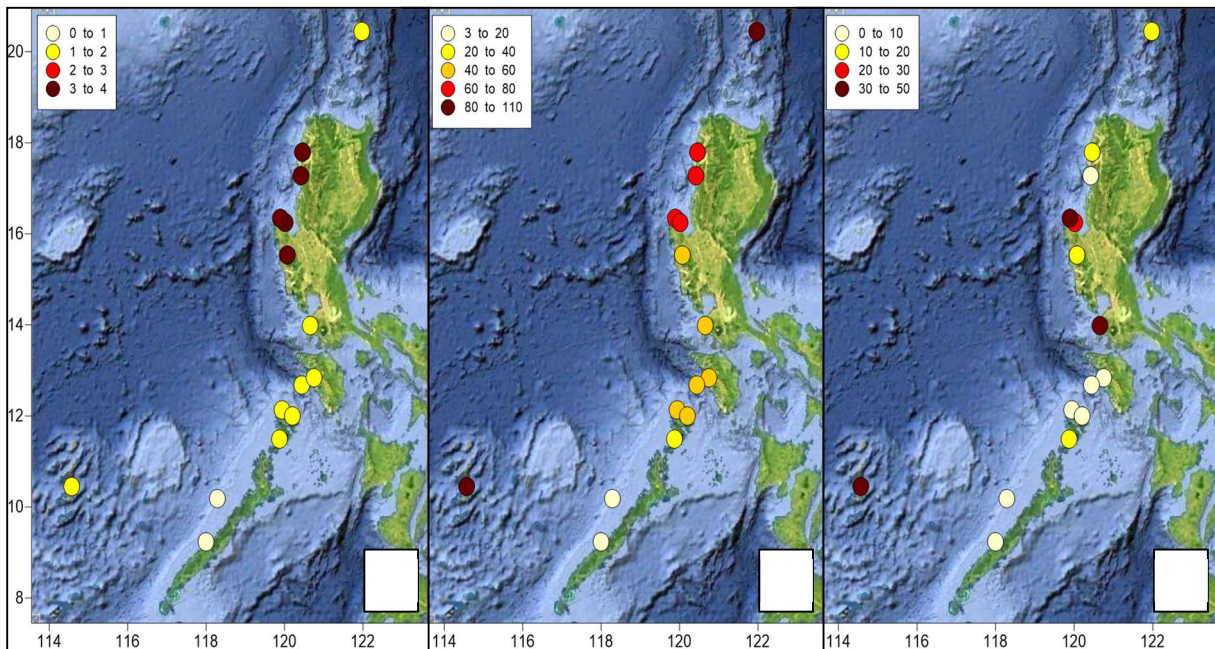


Figure 4.13. Exposure to different threats: a) climate typology (Aliño et al., 2019); storm frequency (Cinco et al., 2016); and fisher density across the South China Sea in Philippine waters (LME). *Color darkens with increase in values.*

4.2.4 Endemic, Endangered, Threatened Species

Mangroves and wetlands in the Philippines are essential habitats for many Red List Threaten Species under the International Union for the Conservation of Nature (IUCN). This includes the hawksbill turtle and the Philippine crocodile. Marine mammal, the Irrawaddy dolphin is also associated with mangrove ecosystem. The occurrence of this species was reported from the inner Malampaya Sound in Taytay (Smith et al., 2004) and Quezon, Palawan (Dolar and Matillano, Unpub.) Irrawaddy dolphins in the Philippines live in habitats that often overlap with human activities and are therefore susceptible to boat collision and entanglement to fishing nets (Gonzales and Matillano, 2008; Lirazan et al., 2022).

Many migratory bird species, the Chinese egret (Vulnerable), Nordmann's greenshank (Endangered), and black-faced spoonbill (Endangered) also depend on mangroves and wetlands. The famous Philippine cockatoo also prefers riverine, coastal, and mangrove forests. This bird is present in El Nido Manage Reserve Protected Area and Puerto Princesa Subterranean River and Natural Park. Its estimated total number of wild populations is estimated at 1,120 individuals. This number is expected to decrease as habitat destruction, poaching, and pet trade remain unregulated (Que et al., 2021).

The coral reefs and seagrass meadows also support a remarkable diversity of threaten marine species. The coral species such as *Anacropora spinosa* (Endangered) and several *Acropora* spp. (Licuanan et al., 2024) are vulnerable to warming seas and human impacts. In Palawan, the globally endangered coral species (*Pectinia maxima*, *Anacropora spinosa*, and *Lobophyllia serratus*) were recorded. The iconic reef-associated species such as the napoleon wrasse and the humphead parrotfish are considered endangered and vulnerable, respectively, due to overfishing and the live reef food fish trade (Chan et al., 2012; Russell, 2004). The whale shark (*Rhincodon typus*), a Vulnerable species and the world's largest fish, has been documented in WPS waters, particularly around Palawan (Guzman et al., 2022). Adding to the list of vulnerable reef inhabitants are several species of giant clams, which are suffering from overharvesting for shells and meat (Dolorosa et al., 2024). These clams are not only ecologically important as reef builders and filter feeders but are also culturally and economically valuable. Their slow growth and reproductive rates make them highly susceptible to exploitation.

The mangrove-associated hawksbill turtle also use the seagrass meadow as nesting and feeding grounds together with the leatherback and loggerhead turtles and the “Least concern” green turtle (previously categorized as endangered) (Mortimer & Donnelly, 2008; Wallace et al., 2013; Casale and Tucker, 2017; Seminoff, 2023). These species face threats from poaching, beach development, and marine debris (PCSD, 2025; Poonian et al. 2016). The Dugong (Marsh & Sobotzick, 2019) also relies heavily on seagrass meadows for food. At present, this marine mammal is threatened by habitat loss, bycatch, and boat strikes (Del Rosario, C. 2022; Guinhawa, 2019). Similarly, endangered and vulnerable seahorses are also present in seagrass meadows and are facing risks from overharvesting and bycatch.

This rich assemblage of endangered and vulnerable species highlights the exceptional biodiversity value of the Philippines waters in the South China Sea LME, but it also underscores its fragility. Conservation of these species requires protecting the habitats they depend on coral reefs, seagrass beds, mangroves, nesting beaches—as well as tackling systemic threats such as overfishing, pollution, climate change, and poorly managed tourism. Collectively, these species highlight the SCS-LME as both a biodiversity stronghold and a region of conservation concern. The summary list of these associated organisms with respective IUCN Redlist status is presented in (Table 4.5).

Table 4.5. Summary list of threaten species associated with the mangroves and wetlands and seagrass and coral reefs ecosystems in the Philippine waters within the South China Sea- large Marine Ecosystems.

Associated Species		Mangroves & Wetlands	Coral Reefs	Seagrass meadows	IUCN Redlist Status
English Name	Scientific Name				

Philippine Cockatoo	<i>Cacatua haematuropygia</i>	+		CR
Philippine Crocodile	<i>Crocodylus mindorensis</i>	+		CR
Bottlenose Dolphin	<i>Tursiops truncatus</i>		+	EN
Irrawaddy Dolphin	<i>Orcaella brevirostris</i>	+	+	CR
Dugong	<i>Dugong dugon</i>		+	CR
Hawksbill Turtle	<i>Eretmochelys imbricata</i>	+	+	CR
Olive Ridley Turtle	<i>Lepidochelys olivacea</i>		+	VU
Leatherback Sea Turtle	<i>Dermochelys coriacea</i>	+		VU
Loggerhead Turtle	<i>Caretta caretta</i>	+		VU
Napoleon Wrasse	<i>Cheilinus undulatus</i>	+		EN
Humphead Parrotfish	<i>Bolbometopon muricatum</i>	+		VU
Barbour's seahorse	<i>Hippocampus barbouri</i>	+		EN
Tiger tail seahorse	<i>Hippocampus comes</i>	+		EN
Hedgehog seahorse	<i>Hippocampus spinosissimus</i>	+	+	EN
Whale Shark	<i>Rhincodon typus</i>	+		VU
True giant clam	<i>Tridacna gigas</i>	+		VU
Horse's Hoof Clam	<i>Hippopus hippopus</i>	+		VU

Legend: Endangered Species (EN) Critically Endangered (CR) Vulnerable (VU)

4.3 Discussion and Conclusions

4.3.1 Priority Transboundary Biodiversity Issues

Biodiversity loss, particularly of threaten megafauna (marine mammals) in the region is alarming. The Irrawaddy dolphin population in Malampaya Sound, Palawan had decreased sharply between 1995 and 2013 (Vira-Mendoza, 2017), although there are no recent abundance assessments available. Among the factors of this decline were attributed to population growth, habitat degradation, and uncontrolled use of fishing gears (Gonzales-Matillano et al., 2017). Meanwhile, dugong stranding incidents showed a declining pattern from 2013 to 2022 (Ramilo et al., 2022). While this may reflect changes in population size, distribution, or reporting effort, the major cause of stranding incident was due to net entanglement. These shifts, alongside persistent threats such as overfishing, habitat loss, pollution, and climate change impacts, underline the urgent need for strengthened conservation and management interventions (see Table 4.5). Climate-related hazards and adaptive capacity of provinces bordering SCS-LME. Bleaching events, typhoon impacts, flooding and qualitative assessments of susceptibility and resilience. Levels are categorized as High (H), Moderate (M), or Low (L).

4.3.2 Risk Assessment and Valuation of Economic Losses

4.3.2.1 Risk Assessment

The assessment of biodiversity significance, socioeconomic importance, and risk levels across selected coastal provinces in SCS-LME highlights varying conservation and management priorities. As shown in Fig. 4.14, Palawan consistently emerged as the most ecologically important province, scoring the highest in biodiversity significance while also ranking high in socioeconomic importance. However, Palawan is also subject to considerable environmental risks, underscoring its status as a critical conservation hotspot. Batangas similarly reflects this pattern, with high biodiversity and socioeconomic values compounded by elevated risks. Pangasinan, although scoring moderately in biodiversity, stands out for its high socioeconomic importance and the highest recorded risk score. This

indicates that the heavy reliance of local communities on coastal resources, combined with anthropogenic pressures, makes the province especially vulnerable and in urgent need of integrated management interventions.

Provinces categorized as low priority include Batanes, Cavite, and Ilocos Norte. These areas generally exhibit low biodiversity significance, lower socioeconomic reliance, and relatively low to moderate risks. Batanes, in particular, shows the lowest values in all three categories, reflecting its relatively isolated status and lower anthropogenic pressure. Cavite, while moderately at risk, ranks low in both biodiversity and socioeconomic importance, reducing its urgency for immediate conservation intervention. Ilocos Norte shows relatively balanced but low-to-moderate scores across all indicators, similarly placing it in the low-priority category.

Overall, the findings suggest that Palawan, Batangas, and Pangasinan require immediate and focused management attention due to the convergence of high ecological and socioeconomic values with elevated risks. Medium-priority areas need preventive and adaptive strategies to curb rising pressures, while low-priority provinces should be continuously monitored to safeguard against future threats. This analysis underscores the importance of a tiered management approach, ensuring that resources and interventions are allocated effectively, balancing ecological protection with socioeconomic sustainability.

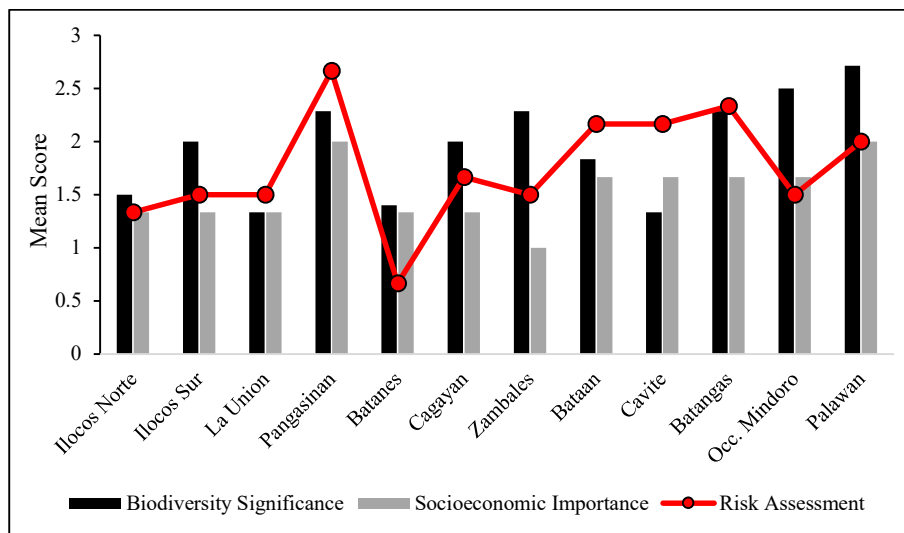


Figure 4.14. Mean scores of biodiversity significance (black bars), socioeconomic importance (gray bars), and risk assessment (red line) across selected coastal provinces in the SCS-LME. Scores are based on a standardized scale (0–3), with higher values indicating greater ecological or socioeconomic importance, and elevated risk levels.

4.3.2.2. Valuation of Economic Losses

The valuation of major coastal and marine ecosystems across the SCS-LME demonstrates the significant economic implications of habitat loss (Table 4.7). Coral reefs, covering 371,210 hectares, emerge as the most valuable ecosystem with an estimated total economic value (TEV) ranging from US\$507 to US\$22,963 per-hectare. A mere one percent loss in the total reef area in SCS-LME, equivalent to 3,712 hectares, could translate into an annual economic loss of US\$1.88 million to 82.24 million. This reflects their critical role in fisheries production, shoreline protection, and tourism. Mangrove forests, occupying 72,584 hectares, also provide considerable value with an estimated TEV of US\$851 to 3,101 per hectare. Losing just one percent of their area (726 hectares) would result in an annual loss between US\$618,000 and 2.25 million, underscoring their importance in sustaining fisheries, providing timber and fuelwood, and mitigating coastal hazards. Seagrass beds, though limited in extent at 23,255 hectares, are highly productive ecosystems valued at US\$934 to 1,590 per hectare. The loss of one percent (233 hectares) would incur US\$217,000 to 370,000 annually in lost benefits, highlighting their role as nursery habitats and carbon sinks.

Wetlands, with the second largest area at 80,866 hectares, show lower per-hectare values of US\$299 to 690, yet a one percent loss (809 hectares) still amounts to US\$243,000 to 558,000 annually. While wetlands may appear economically undervalued compared to reefs or mangroves, their ecological functions such as water purification, flood regulation, and support for migratory species are vital and often underestimated in monetary terms. Overall, the results indicate that coral reefs carry the greatest potential economic loss, but mangroves, seagrasses, and wetlands each provide essential services that sustain coastal communities. Protecting these ecosystems is not only an ecological necessity but also an economically sound strategy, as even small-scale degradation leads to millions of dollars in annual losses.

Table 4.6. Estimated economic value of major coastal and marine ecosystems in terms of total area, per-hectare value, and projected annual economic loss from a 1% decline in area. Values are expressed in US dollars per hectare per year, highlighting the potential costs of ecosystem degradation.

	Total Area (Ha)	Total Economic Value (US\$/Ha)	1% of Total Area (Ha)	Value of 1% Loss (US\$/Ha/Yr)
Coral Reefs	371,210	507 - 22,963	3,712.1	1,882,035 - 82,240,952
Seagrasses	23,255	934 - 1,590	232.6	217,202 - 369,638
Mangrove Forests	72,584	851 - 3,101	725.8	617,762 - 2,250,975
Wetlands	80,866	299 - 690	808.7	242,789 - 557,975

4.3.3 Current Management and Institutions

Management of coastal and marine ecosystems of the Philippine Seas in the SCS-LMEs is a collective effort. It is shared among national agencies (DENR-BMB, BFAR), local governments, NGOs, and academic partners. Local government units (LGUs) play a central role in day-to-day stewardship, while broader support comes from institutions and national agencies such as the DENR-Biodiversity Management Bureau (DENR-BMB). Over the years, these partnerships have helped establish and strengthen Marine Protected Areas (MPAs), many of which are showing clear signs of success, healthier coral reefs and increased fish populations within their boundaries. However, offshore reefs in the KIG face weak enforcement and governance gaps.

These efforts are further boosted by the work of non-governmental organizations (NGOs) and academic institutions, which provide technical support, conduct ecological monitoring, and help build local capacity through training and research. However, challenges remain. The division of responsibilities among different agencies can sometimes lead to gaps in coordination and enforcement, particularly in areas outside of MPAs. As a result, some important ecosystems may fall through the cracks. Strengthening institutional coordination, enforcement, and science-based planning is essential to scale up conservation gains.

4.3.4 Gaps and Priority Challenges

- **Incomplete temporal data for some provinces:** While Palawan has consistent data from 2015 to 2023, other provinces bordering the South China Sea-LME lack time-series data on mangrove forest cover. Figure 6 highlights the absence of reliable data for these regions, limiting comparative analysis and targeted conservation efforts.
- **Limited ground validation:** The report on mangrove and seagrass cover relies heavily on remote sensing (e.g., Landsat-derived Mangrove Vegetation Index). While useful, these methods may miss finer ecological details without ground-truthing.
- **Fluctuating mangrove cover:** Although there are periods of regrowth (e.g., 1990, 2003), the overall trend from 1918 to 2020 is a net decline. This instability poses a challenge for long-term conservation planning.
- **Data accessibility and integration:** The report pulls from various sources (UNEP, PSA, NAMRIA, etc.), but integration and standardization of these datasets remain a challenge for national monitoring.

- **Conservation inequity across provinces:** Palawan shows strong conservation outcomes, but other provinces lack both data and documented efforts, suggesting uneven implementation of mangrove protection strategies.
- **Species loss and biodiversity threats:** The reduction in recorded species may indicate biodiversity loss, which could compromise ecosystem resilience and services.

Although site-specific data on mangrove forest cover are available, the biophysical characteristics of the sites (as area mapping, tree inventory, associated organisms, and carbon stock) remain understudied or lacking. These data are vital in the ecosystem valuation. In cases, when data are available, the monitoring practices varied widely, making it difficult to compare data across sites or track long-term changes accurately. There's also limited information on the status of key species like dugongs and sea turtles, which makes it harder to protect them effectively. Planning that links activities on land and sea is still lacking, despite their close ecological connection.

4.3.5 Recommended Priority Actions Including Regional Cooperation

- **Strengthening legal and institutional frameworks for ecosystem-based management:** strengthen the laws and institutions that guide how we manage our coasts and oceans, ensuring that planning happens not just at individual sites, but across entire seascapes.
- **Expanding and connecting MPAs across ecological corridors:** MPAs should be expanded and better connected, especially between important ecological zones like the Calamianes, KIG, and the Spratlys, where species and larvae naturally move and interact.
- **Standardizing monitoring protocols for corals, seagrass, mangroves and key wildlife across the Philippine Seas in the SCS-LME and SCS region:** while standard monitoring protocols are already in use in the Philippines, it is crucial to promote its consistent application across the country and within the broader South China Sea region, and to establish similar standardized approaches for other key marine wildlife such as dugongs and sea turtles—to ensure reliable, comparable data to guide science-based decisions;
- **Engaging local communities in enforcement and stewardship:** continue investing in community-based enforcement and capacity-building initiatives to empower local stakeholders. Strengthen their role in monitoring fishing pressure, promoting compliance, and supporting evidence-based management decisions at the local level.
- **Integrating climate adaptation into reef and seagrass management:** as climate change intensifies, we must also weave climate adaptation into how we care for reefs, seagrass, and mangrove areas, making sure they remain resilient in the face of rising seas and warming waters; and
- **Enhancing transboundary cooperation under the SCS-SAP to address shared threats and sustain ecological connectivity:** because marine ecosystems don't follow national boundaries, stronger cooperation between countries is essential, working together under frameworks like the South China Sea-Strategic Action Programme (SCS-SAP) to protect our shared ecological heritage.

4.4 Methodology and Analyses

This report brings together a rich mix of data, from field surveys to scientific models—to provide a clearer picture of the state of mangroves, wetlands, coral reefs, and seagrasses within the Philippine waters of the SCS-LME. Data sources include both past and recent field surveys, long-term monitoring results from 2006 to 2022 within local Marine Protected Areas (MPAs) (Campos et al., 2022), and scientific modeling tools. Mangrove and seagrass conditions were evaluated through a combination of remote sensing techniques and the transect-plot method, allowing for both spatial mapping and ground validation of habitat extent and condition. Mangrove cover loss was computed to track changes over time, while risks and threats to coastal ecosystems were systematically summarized and tabulated to highlight key pressures. The analysis followed the established framework of the Transboundary Diagnostic Analysis (TDA) guidelines, ensuring a structured assessment of ecological conditions, drivers of change, and implications for management and conservation.

For coral reefs, standardized underwater survey techniques were employed. The line-intercept transect (LIT) method was used to quantify changes in coral cover and benthic composition, while fish visual census methods were applied to assess fish biomass, abundance, and diversity. Spatial distribution patterns of reef fish and benthic parameters across Philippine waters in the SCS LME were compiled from recent reports (Arceo et al., 2024). Temporal comparisons of reef condition between 2003–2007 and 2015–2018 were generated using datasets from SAP-SCS (2008), CRINP (2008), Licuanan et al. (2019), and Arceo et al. (2024). Reef health status was assessed against updated national benchmarks established by Licuanan et al. (2017), providing a consistent basis for evaluating ecosystem trajectories and management needs.

To understand how reefs are connected across wider regions, the study also looked at larval dispersal patterns to show how coral and other larvae move with ocean currents. This includes findings from oceanographic models (like those by Dorman et al., 2016) and genetic research, which show that reefs in Palawan, the Spratlys, and other parts of the South China Sea are ecologically linked. Different risks were analyzed using the Philippine Climate-Ocean Typology established by Aliño et al. (2019), storm frequency (Cinco et al., 2016) and fisher density (fishers/km²) was computed using the number of registered fishers and total land area by locality in the report by Arceo et al., 2024. Altogether, this multi-layered approach helps us better understand not just reef conditions, but also their ecological importance and what kind of protection or management they need most.

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Chapter 4 Annexes

Annex 4.A. List of Mangrove Species in the Philippines

Table 4.A.1. List of Mangrove Species found in the Philippines

Family	Species	Primavera et al (2000)	FAO (2005)	Giesen et al. (2007)
Acanthaceae	<i>Acanthus ebracteatus</i>	+	+	+
	<i>Acanthus illicifolius</i>	+	+	+
Avicenniaceae	<i>Avicennia alba</i>	+	+	+
	<i>Avicennia eucalyptifolia</i>	-	-	+
	<i>Avicennia lanata</i>	-	-	+
	<i>Avicennia marina</i>	+	+	+
	<i>Avicennia officinale</i>	+	+	+
	<i>Avicennia rumphiana</i>	+	+	-
Bombacaceae	<i>Camptostemon philippinensis</i>	+	-	-
	<i>Camptostemon schultzii</i>	+	+	+
	<i>Lumnitzera littorea</i>	+	+	+
	<i>Lumnitzera racemosa</i>	+	-	+
Euphorbiaceae	<i>Lumnitzera rosea</i>	+	+	+
Lythraceae	<i>Exoecaria agallocha</i>	+	+	+
Sonneratiaceae	<i>Pemphis acidula</i>	+	+	+
	<i>Sonneratia alba</i>	+	+	+
	<i>Sonneratia caseolaris</i>	+	-	-
	<i>Sonneratia gulngai</i>	+	-	-
	<i>Sonneratia lanceolata</i>	+	+	+
Meliaceae	<i>Sonneratia ovata</i>	+	+	+
	<i>Xylocarpus granatum</i>	-	+	-
	<i>Xylocarpus mekongensis</i>	+	+	+
	<i>Xylocarpus moluccensis</i>	-	+	+
Myrsinaceae	<i>Xylocarpus rumphii</i>	+	+	+
	<i>Aegiceras corniculatum</i>	+	+	+
Myrtaceae	<i>Aegiceras floridum</i>	+	+	+
Palmae	<i>Osbornia octodonta</i>	+	+	+
Plumbaginaceae	<i>Nypa fruitican</i>	+	-	-
Pteridaceae	<i>Aegialitis annulata</i>	+	+	+
	<i>Acrostichum aureum</i>	+	+	+
Rhizophoraceae	<i>Acrostichum speciosum</i>	+	+	+
	<i>Bruguiera cylindrica</i>	+	-	-
	<i>Bruguiera exaristata</i>	+	+	+
	<i>Bruguiera gymnorrhiza</i>	+	-	-
	<i>Bruguiera hainesii</i>	+	+	+
	<i>Bruguiera parviflora</i>	+	+	+
	<i>Bruguiera sexangular</i>	+	+	+
	<i>Ceriops decandra</i>	+	+	+
	<i>Ceriops tagal</i>	+	+	+
	<i>Kandelia candel</i>	+	+	+
	<i>Rhizophora apiculata</i>	+	-	-
	<i>Rhizophora lamarckii</i>	+	+	+
	<i>Rhizophora mucronate</i>	+	+	+
	<i>Rhizophora stylosa</i>	+	+	+
	<i>Scyphiphora hydrophyllacea</i>	+	+	+
	Rubiaceae	<i>Heritiera littoralis</i>	-	+
<i>Brownlowia argentata</i>		-	-	+
<i>Brownlowia tersa</i>		-	-	+
Tiliaceae				
17	48	41	36	39

Annex 4.B. List of Seagrass Species in some Provinces in the Philippine Waters of SCS-LME.

Table 4.B.1. List of Seagrass Species found in some Provinces in the Philippine Waters of SCS-LME

Seagrass Species	Pal	Bat	Pang	Zam	Cag	Occ. Min
Family Potamogetonaceae						
<i>Cymodocea rotundata</i> Ehrenberg and Hemprich, ex Ascherson	/	/	/	/	/	/
<i>Cymodocea serrulata</i> (R. Brown) Ascherson and Magnus	/			/		/
<i>Halodule pinifolia</i> (Miki) den Hartog	/	/	/			/
<i>Halodule uninervis</i> (Forsk.) Ascherson	/	/	/	/	/	/
<i>Syringodium isoetifolium</i> (Ascherson) Dandy	/	/	/	/	/	/
<i>Thalassodendron ciliatum</i> (Forsk.) den Hartog	/					
Family Hydrocharitaceae						
<i>Enhalus acoroides</i> (L. f.) Royle	/	/	/	/	/	/
<i>Halophila beccarii</i> Ascherson						
<i>Halophila minor</i> (Zollinger) den Hartog	/	/				
<i>Halophila decipiens</i>						
<i>Halophila gaudichaudii</i>						
<i>Halophila ovalis</i> (R. Brown) Hooker f	/	/	/	/	/	/
<i>Halophila ovata</i>						
<i>Halophila spinulosa</i> (R. Brown) Ascherson						
<i>Thalassia hemprichii</i> (Ehrenberg) Ascherson	/	/	/	/	/	/
Family Ruppiaceae						
<i>Ruppia maritima</i>						
Species Richness	10	8	7	7	6	8

Annex 4.C. Expanded Explanatory Text MSPLS

Coastal Wetlands

Introduction

The South China Sea is a semi-enclosed large body of water that supports unique habitats and ecosystems that are amongst the most biologically diverse shallow-water marine ecosystems globally. The richness and productivity of the South China Sea and associated environments are seriously threatened by high population growth, pollution, overharvest, and habitat modification, resulting in high habitat loss rates and impairment of living resources' regenerative capacities. The socio-economic impacts of environmental deterioration are significant for the economies of this region.

The countries of the region (Cambodia, China, Indonesia, Thailand, Philippines and Vietnam) sought the assistance of UNEP and the Global Environment Facility (GEF) in preparing a Transboundary Diagnostic Analysis (TDA) of the issues and problems and their societal root causes as the basis for the development of a Strategic Action Programme (SAP) which was inter-governmentally adopted in 2008. During the first phase of the project, the Philippines through the DENR Biodiversity Management Bureau (BMB), has signed a Memorandum of Understanding with UNEP to act as Specialized Executing Agencies (SEA) for national level activities of the project. At this point, that is 2024, the Society for the Conservation of Philippine Wetlands (SCPW), who shares mandate and interest in coastal ecosystem conservation with the SCS SAP project, was recognized as the implementation partner for selected activities, for lack of any communication from the DENR to continue with the SCS SAP Project. Recognizing that the SCPW does not have the institutional assets that DENR possesses, the SCPW and SCS SAP Project agreed to scale down the outputs, number of sites, and activities which was previously agreed upon with DENR during the planning and inception phase. This new arrangement, which minimizes logistical, personnel, and operational requirements, was envisioned to ensure that the SCPW can deliver its commitments under the Agreement with the resources available for implementation. SCPW will thus be directly involved in delivering the project outputs for the wetland site in Malampaya Sound Protected Landscape and Seascape (MSPLS).

The SCPW will thus support the implementation of Component 1 of SCS SAP Project particularly focusing on promoting integrated management of coastal wetland including habitat restoration, reducing habitat degradation and strengthening habitat protection; more specifically, sub-component 1.4 Integrated management of 813,647 ha of **coastal wetland** at 19 sites (in this case, only MSPLS), including habitat restoration and protection strengthened at priority locations. Implementation of Components 2 & 3 will also be supervised by SCPW.

The Malampaya Sound Protected Landscape and Seascape (MSPLS)

I. Background & Location

The MSPLS covers a total area of 200,115 ha inclusive of the open sea 10 km distance from the shoreline to the north and west into the West Philippine Sea. The marine portion covers 111,339 ha while the terrestrial portion is 88,776 ha. Malampaya Sound Protected Landscape and Seascape (MSPLS) was established under the NIPAS Act (RA 7586) framework by the National Integrated Protected Areas Programme (NIPAP). Presidential Proclamation No. 324, signed by President Joseph Estrada last July 12, 2000, establishes the Malampaya Protected Land and Seascape.

The MSPLS shares common borders with Lake Danao in Taytay to the east, the El Nido-Taytay Managed Resource Protected Area (ENTMRPA) to the north, and the Municipality of San Vicente with four of its barangays (New Canipo, Sto. Niño, Alimangan, San Isidro) to the south. The portion of open sea to the northwest was included

in the PA to maintain the stability of marine resources in the area and to prevent the intrusion of commercial fishers as well as minimize illegal activities (PAMP, 2025-2034).

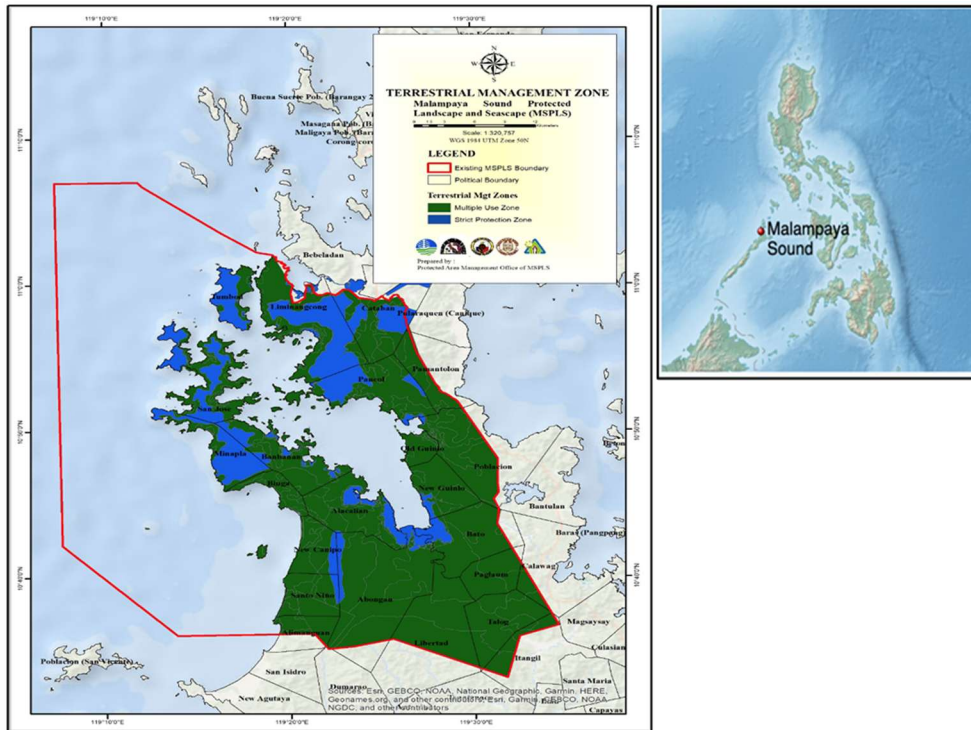


Figure 4.C.1 Location map of the MSPLS and its terrestrial management zones (PAMP, 2025-2034)

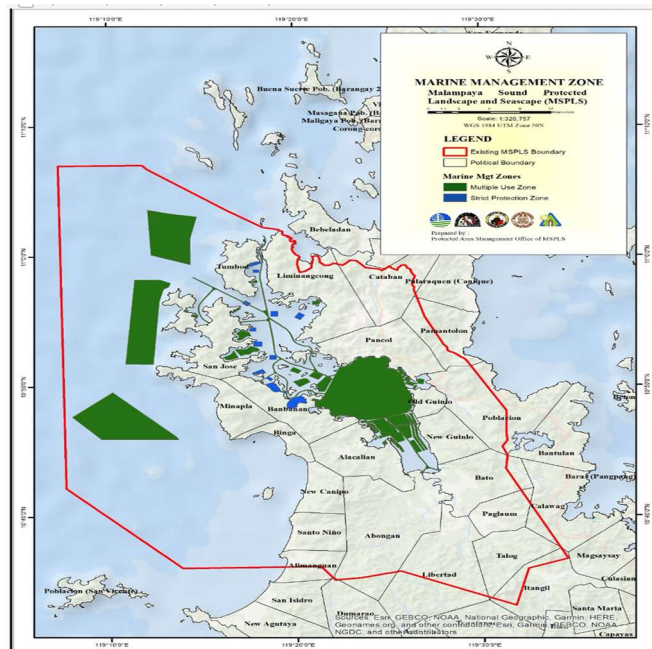


Figure 4.C.2 Marine management zones (PAMP, 2024-2034)

Marine & Coastal Wetlands.

In the coastal wetlands, the mudflats / tidal flats are characterized as areas along the coasts that are unvegetated and exposed substrate with sandy and muddy sediments that undergo regular tidal inundation (Ancog et.al undated). Despite these habitats being lost due to anthropogenic activities such as conversion to fishponds for aquaculture and land reclamation, they are poorly studied, hence data for them can rarely be found in the country (Ancog et.al, n.d.).

Threatened marine mammalian and reptilian species were found inhabiting the MSPLS. Two species of dolphins have been observed in the Malampaya Sound – the Bottle-nosed Dolphin (EN: *Tursiops truncatus*), or Lumod Lumod in the local language, seen in the Outer Sound, while the Irrawaddy Dolphin (CR: *Orcaella brevirostris*) has been observed in the Inner Sound. Dugongs (CR: *Dugong dugon*) have been sighted in seagrass beds of the MSPLS. The Hawks Bill (CR: *Eretmochelys imbricata*) and Green (EN: *Chelonia mydas*) Sea Turtles and the Olive Ridley (VU: *Lepidochelys olivacea*) were found to nest in the western coasts of the MSPLS. They visit their nesting sites regularly to lay eggs from December to March (MSPLS GMP 2019). Details are in Chapter 4.2.4.

The live coral reefs in the Sound cover only 17%, which is considered poor. The coral reefs in the west coast are in better condition. There are 27 genera of coral under 13 families that are found in the area (MSPLS GMP 2019). The rare Giant Clam (*Tridacna spp.*) was also found to thrive in the Sound (Vicente 2024). There were 262 species of fish identified (Vicente, 2024) as of 2024.

Landscape.

There are 11 mammalian threatened species (CR, EN, VN), 5 amphibian and 10 avifauna species found therein. Details are also found in chapter 4.2.4.

Landscape and Topography of the MSPLS

Malampaya Sound has moderately rolling hills with slopes ranging from 8 percent to 30 percent. The southwestern coast has soft white sands, coves, bedrocks and is relatively flat and rising gradually to undulating hills. Altitude ranges from 100 to 500 meters, which form the watershed divide of the Sound. Above 200 meters, the area is naturally stony granite (MSPLS GMP, 2019; IUCN-MMPATF, 2022).

The elevation rises abruptly from sea level to 1,013 meters at Mt. Capoas, the highest peak of the landscape along the northwestern coast of the Sound. The topography in the northern section of Mt. Capoas drops in elevation ranging from 350 to 100 meters above sea level. Mt. Capoas provides a unique habitat as the only mossy forest outcrop (MSPLS GMP, 2019).

The coast rises to the watershed ridge about 318 meters at Olongo Peak. Steep rocks characterize its western coastline and the northern part has a gentler gradient. The watershed ridge along the Inner Sound is not as high and only on moderate slopes. The forest is intact although the cover is patchy while the forest cover is excellent on slopes along the southwestern part. White fine sand interspersed with rocky sandstone describe the coast. Granite and limestone formations are present (MSPLS GMP, 2019).

At the head of the Sound, the gently rolling hills broaden out to an extensive broad plain. These areas are used for agriculture. In the southern section, minor plains are narrow and randomly occur between patches of land with slopes ranging from nearly level to gently sloping with an elevation ranging from three to 100 meters (MSPLS GMP, 2019).

The hills in the barangays of New Guinlo, Bato and Paglaum are characterized as level to gently sloping, sloping to undulating, and undulating to rolling. Hills around the Sound are predominantly metamorphic. The areas with elevation less than 150 meters are utilized for upland and orchard farming (MSPLS GMP, 2019).

The Sound’s landscape is significantly covered with forest with dipterocarps as the dominant trees. It serves as a wildlife corridor connection between El Nido and central Palawan forests. The landscape contains some of the most important biological resources with national significance (MSPLS GMP, 2019).

Residual forest patches occur on hills with elevations greater than 150 meters that form the watershed ridge along barangays Talog, Libertad, Paglaum, Abongan and Alacalian in Taytay. Forest cover is fairly good on these slopes since most of the agricultural activities are in the broad plains that extend into the mangrove delta of the Buwaya Sound. An estimated 20% of the protected area is covered by old growth forest and 25.7% by residual forest (MSPLS GMP, 2019).

Generally, there are five major types of soil found in Taytay and San Vicente: the Busuanga Loam, Coron Clay Loam, the Sibuyan Silty Clay and Silty Clay Loam (MSPLS GMP, 2019).

Seascape and Topography of the MSPLS

The 34 km long Sound is divided into two sections, a salt water Outer Sound and a brackish Inner Sound. The Outer Sound varies in depth from about 22 meters to 46 meters and the Inner Sound varies from 4 m to 16.5 meters. The Inner Sound is 9 km wide and covers a surface area of 24,500 hectares. (MSPLS GMP, 2019).

The Malampaya Sound has two entrances – the Worcester Strait, which is the main entrance, has strong tidal streams and a fairway that is quite deep; and the Endeavor Strait that has a depth of 8.7 m (29 ft) in the fairway. There are about 50 islands and rock formations in MSPLS, 13 of which separate the Outer and the Inner Sound. Most of these islands range from 50 to 100 meters above sea level, mostly farmed or logged, some planted with cashew. Tukuran Island is the largest with significant forest cover and habitat to some endangered wildlife. Wedge Island and Lison Rock are observed by communities to be bird sanctuaries. Imuruan Island is known for its white fine sand (MSPLS GMP, 2019; PAMP, 2025-2034).

Sediment of the Sound is of soft, fine mud from the closed end (southeast) to the open end (northwest). The former exhibits dark green coloration while the latter has light green coloration (MSPLS GMP, 2019).

Along the western coast, several seagrass beds are present. Dugongs, dolphins, whales and sea turtles have been observed at Miñon and Imuran Bays. The soft sands along the west coast are breeding habitats of sea turtles (MSPLS GMP, 2019).

The live coral reefs in the Sound cover only 17%, which is considered poor. The coral reefs in the west coast are in better condition. There are 27 genera of coral under 13 families that are found in the area (MSPLS GMP, 2019).

More than 156 species of fish are found in the Sound of which 60 species are considered to be first class species with high commercial value (MSPLS GMP 2019). There are already 262 species of fish identified (Vicente, 2024). Below (Table 4.A.1) shows the marine and other aquatic products that are harvested as alternative livelihood.

Table 4.C.1. Other Sources of Income from Marine and Aquatic Products (PAMO, MSPLS, 2024)

Resource	Type of Product	Frequency of Harvest	Market
1. Jellyfish	Processed jellyfish products	Seasonal; May-July	Manila, Japan, China and Korea
2. Seaweeds		Jan – May inner MSPLS	
3. Lato		No commercial value	
4. Bangus Fry		Catching of Sabalo fry is prohibited in MSPLS	

5. Blue Crabs	Crab meat	Year round	Manila and within Palawan
6. Mangrove Crab		Year round	
7. Sea Cucumber		Seasonal from Jan.-June	Local community, Taytay
8. Lobster		June – December outer MSPLS	Manila
9. Shrimp		Feb- June inner MSPLS	Manila and within Palawan
10. Squid		Nov.–June outer MSPLS; Feb-May – inner MSPLS	Manila and within Palawan
11. Green Mussel	Dried and Fresh	July – Dec inner MSPLS Year-round	Manila and within Palawan
12. Other Shellfish	Kabitsin, Kibaw, Balilit, Saka-saka	Year round	Local Community, within Taytay

Mangroves and Coastal Wetlands

In the coastal wetlands, the mudflats / tidal flats are characterized as areas along the coasts that are unvegetated and exposed substrate with sandy and muddy sediments that undergo regular tidal inundation (Ancog et.al undated). Despite these habitats as being lost due to anthropogenic activities such as conversion to fishponds for aquaculture and land reclamation, they are poorly studied, hence data for them can rarely be found in the country (Ancog et.al, n.d.).

There are several old growth mangrove forests containing about 16 species (PAMP, 2025-2034) that are found in the estuaries of four major river systems - Abongan, Alacalian, Bato and Pinagupitan, which flows into the head of the Inner Sound. There are about 30 river systems inside the MSPLS (MSPLS GMP 2019). Mangroves in the Inner Sound are made up of species such as Bakuauan- babae (*Rhizophora mucronata*), Bakauan-lalake (*R. apiculata*), Bani (*Milletia pinnata*), Busain (*Bruguiera gymnorrhiza*), Buta-buta (*Excoecaria agallocha*), Dungon-late (*Heritiera littoralis*), Kulasi (*Lumnitzera racemosa*), Langarai (*Bruguiera parviflora*), Malatangal, Pagatpat (*Sonneratia alba*), Pedada (*S. caseolaris*), Pototan (*B. sexangula*), Sagasa, Tabigi (*Xylocarpus granatum*), and Tangal (*Ceriops tagal*). The Mangrove forests are estimated to cover 3.9% of the protected area (MSPLS GMP, 2019).

Vicente (2024) citing from a study by PCSDS (2006a), identified only 9 species of mangroves in the Sound, namely *Rhizophora apiculata* Blume, *Rhizophora mucronata* Poir, *Xylocarpus granatum* J. Koenig, *Bruguiera cylindrica* Blume, *Ceriops tagal* C.B. Robinson, *Bruguiera gymnorrhiza* Lam, *Excoecaria agallocha* L, *Scyphiphora hydrophyllacea* C.F.Gaertn, and *Lumnitzera littorea* Voigt.

Table 4.C.2. Stand Estimates and species of mangroves in Malampaya Sound (PCSD, 2006)

Barangay	No. of Trees/ha	Stand Volume (m ³ Ha ⁻¹)	SV Class	Species present
Old Guinlo	1037	361.44	High	Ct, Bc
New Guinlo	696	127.15	Moderate	Ct, Ra Rm
Alacalian	702	367.8	High	Ct, Ra, Rm, Xg, Bg, Bc, Ll, Sh
Abongan	429	388.18	High	Bs, Ra, Ct, Xg, Bg, Ea
Banbanan	329	274.41	High	Bg, Ra
San Jose	116	120.59	Logged over to High	Bg, Ra, Rm
Liminangcong	322	278.38	Moderate to High	Ct, Ra, Rm
Pancol	566	184.56	Moderate to High	Ct, Ra, Rm

Mean	524.63	262.81	High
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Legend: Ra = *Rhizophora apiculata*, Rm = *Rhizophora mucronata*, Xg = *Xylocarpus granatum*, Bc = *Bruguiera cylindrica*, Ct = *Ceriops tagal*, Bg = *Bruguiera gymnorrhiza*, Ea = *Excoecaria agallocha*, Sh = *Scyphiphora hydrophyllacea*, and Ll = *Lumnitzera littorea*

Several barangays exhibited a moderate to high mangrove cover. These include Old and New Guinlo, Alacalian, Abongan, Banbanan, Liminangcong, and Pancol. Malampaya mangroves have an average density of 525 trees per hectare. All barangays, except San Jose, experienced extensive illegal logging. Dela Peña et al. (2015b cited by Vicente, 2024) found that 46% of the mangrove areas are in healthy condition. Only Bgy Banbanan has good mangrove forest cover (Vicente, 2024).

The total area covered by the mangroves within the MSPLS is 3,338 has. Liminangcong has the highest mangrove forest cover at 473.75 ha among the four barangays. However, along with the other two barangays, its perceived condition is fair. Only Banbanan has good mangrove forest cover (Dela Peña et al., 2015). Dela Peña et al. (2015) further reported that the overall perceived condition of its 802-hectare (ha) mangrove forest is fair due to ongoing wood harvesting for charcoal making and house repair (dela Peña et al., 2015).

Fisherfolk recognizes the association between declining fish populations and shrinking mangrove areas. Communities in Malampaya Sound are also socially and economically dependent on forest resources and non-timber forest products for building materials and traditional fishing gear. Some of these are bamboo, wood, rattan, *pandan*, unprocessed rattan poles, *nipa* and timber, and the exploitation of many of these materials does not respect government regulations, because no levies are paid (Pilien & Walpole, 2003).

Coral Reefs & Seagrasses

Seagrass.

Malampaya Sound harbors 8 species of seagrasses and various species of corals and macroinvertebrates including the rare giant clam *Tridacna spp* (Vicente, 2024). Generally, its 211 ha of seagrass bed is disturbed (dela Peña et al., 2015).

In Malampaya Sound seagrass beds cover an area of about 21 km² (PNSS, 2004 cited by Vicente 2024) mainly in Barangays Banban, Bucal, Liminangcong, San Jose, and Tumbod (PCSDS 2006; dela Peña et al. 2015b cited by Vicente 2024). Eight of the 13 seagrass species in the Philippines are found in the Sound. These species are: *Enhalus acoroides* Royle, 1839; *Cymodocea rotundata* Asch. And Schweinf.; *Cymodocea serrulata* Ascherson and Magnus, 1870; *Halodule pinifolia* Hartog; *Halodule uninervis* Ascherson; *Halophila ovalis* Hooker, 1858; *Syringodium isoetifolium* Dandy; and *Thalassia hemprichii* Ascherson, 1871. In 2004, the outside of the Sound had a percentage cover of these species ranging from very poor to poor (8–30%). However, the monospecific stands of *E. acoroides* thickly cover the inner Sound (PCSDS 2006a; dela Peña et al. 2015b cited by Vicente, 2024).

The growth of seagrass is sparse in Malampaya Sound and less diverse, particularly in the Inner Malampaya Sound, as reported by PCSDS (2006a). The seagrass in Barangay Banbanan, located in the Inner Sound, was described as pristine by FGD participants and key informants. The seagrass bed of Sitio Bucal in Barangay Liminangcong was said to be diverse and well-developed as it covers a wide area of the sandy substratum (PCSDS, 2006a). However, the seagrass beds of Barangay Liminangcong as a whole is currently characterized as disturbed by its fishers. The villages of San Jose and Tumbod have seagrass beds, having less than a hectare, that are disturbed and in altered conditions, respectively (dela Peña et al., 2015).

Coral Reef.

There are extensive coral features along the western coast all the way north to the west coast of Tukuran Island. Wedge and Imuruan Islands have broad coral cover in excellent condition (MSPLS GMP, 2019). In the Outer Sound, the fringing reefs are found in Barangays Liminangcong, Tumbod, San Jose, and Bambang. There has been no published report on how many species of corals are present in the area; however, it was reported in 2004 that coral cover ranges from 30 to 75% (CHE-UPLB, 2015). A similar report was published by the PCSDS (2006a; 2006b) accounting for the coral reefs from fair to good condition. Around 1,632 ha of coral reefs are in poor condition (dela Peña et al. 2015). However, the latest published surveys reported that the condition in the Sound worsened from fair to poor (Matillano et al. 2014; dela Peña et al. 2015a cited by Vicente 2024), except in areas on the Outer Sound like Liminangcong where corals remained in excellent condition (Matillano et al. 2014 cited by Vicente 2024). Among the four selected MSPLS barangays, only Bambang's coral reef area, which also happens to be the smallest in size at 24 ha, has fair coral cover. Located at Noble Hump Island, the reefs are said to be protected by the island's owner (Dela Peña, 2015).

Associated reef fish are also abundant in the Sound. There are 262 species of fish recorded (Balisco et al., 2014; Dolorosa and Matillano, 2014 cited by Vicente, 2024), of which 101 were target species, 97 were indicator species, and 64 were major species. Pomacentrids and chaetodontids mostly dominate the fish population. The Sound harbors more fish species than the reefs found in the adjacent Taytay, Turtle, Binunsalian, and Bacuit Bays. It is estimated that the reefs have a high productivity that can yield fish biomass of 59.94 t.km² (Vicente, 2024).

Macroinvertebrates also inhabit the area with 10 species recorded including the rare *Tridacna* spp. Bruguière, 1797, and *Conus* spp. Linnaeus, 1758 (Dolorosa and Matillano, 2014 cited by Vicente, 2024). The presence of the destructive Crown of Thorns Starfish *Acanthaster planci* Linnaeus 1758, were also noted (Vicente, 2024).

Deterioration has been observed among the reefs around the Sound over time. The use of beach seine (baring) and turbid waters in Inner Malampaya Sound have generally contributed to its deterioration in Bambang. Liminangcong and Tumbod's poor coral reef cover is due to rampant use of Danish seine (hulbot-hulbot), sodium cyanide, and dynamite in fishing. In San Jose, "baring" is said to be used in addition to hulbot-hulbot along Worcester Strait and dynamite fishing in Bolalo Bay. These fishing methods tend to destroy coral reefs in these areas. Generally, the reportedly present poor coral reef conditions in four selected MSPLS barangays are worse than their previous fair to good conditions as reported by PCSDS (2006a) and dela Peña et al. 2015. In 2015, the remaining corals were in either poor or fair condition (PCSDS 2006a; Matillano et al., 2014; dela Peña et al., 2015b cited by Vicente, 2024).

Biodiversity hotspots and sensitive areas

Located in Figure 4.A.3 below are the biodiversity hotspots in terms of ecosystems such as coral, seagrass, mangroves, and sensitive areas where nesting sites of sea turtles and sightings of threatened marine mammals such as the Irrawaddy Dolphin and the Bottle-nose Dolphins have been identified. Biodiversity hotspots and sensitive areas are found mostly inside the Inner and Outer Malampaya Sound, while the western coastline is found to be nesting sites of the sea turtles. The Risso's Dolphin had been observed at the western coast in a cove in Bgy Minapla.

Coral reefs are mostly found in the Outer Sound in island fringes and coves where they are mostly protected from strong currents in the monsoon months. Mangroves are found in the Inner Sound mostly lining the coastal mudflats, where rivers empty into the Sound. Seagrass beds are found in sheltered coves in Barangays Bambang, Pangcong and Liminangcong.

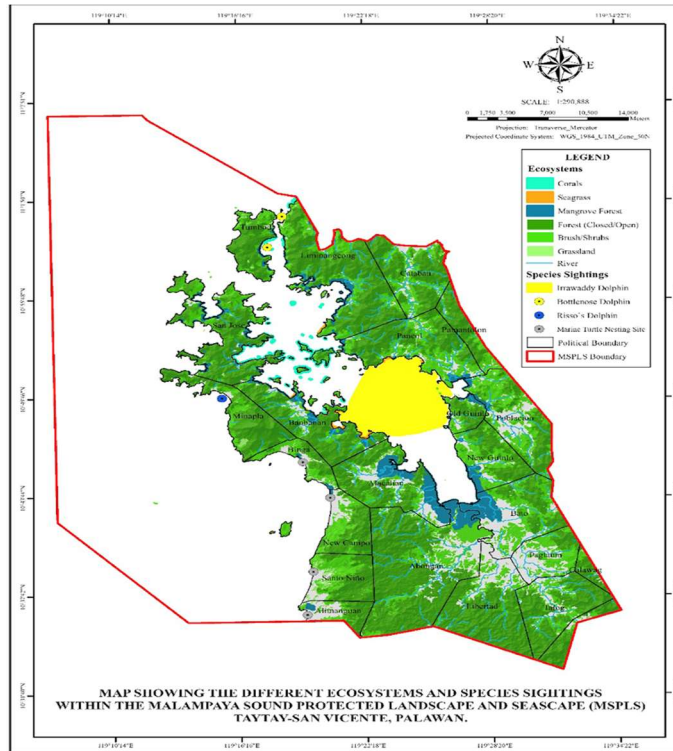


Figure 4.C.3. Sensitive areas and biodiversity hotspots in the MSPLS (PAMP, 2025-2034).

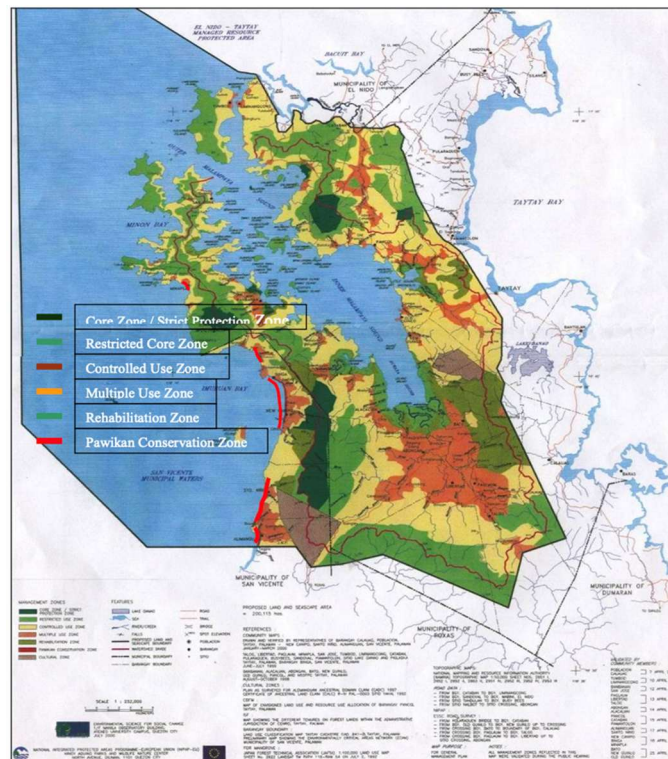


Figure 4.C.4. Management zones identified in the MSPLS in yr2000 which can be translated into biodiversity hotspots and sensitive areas (MSPLS Mgt. Plan, 2000).

Figure 4.A.4 above shows the management zones identified for MSPLS in yr2000. As shown, which the present time MSPLS management zones have adopted, are the sensitive areas mostly found in the western coastline where nesting sites of sea turtles are located. Restricted core zones are also located at the head of the Inner Sound where large areas of mangroves are found. Corals and Seagrass beds are still found in the areas where the current PAMP 2024-2034 have located them.

Endemic, Endangered, Threatened Species

PCSDS (2006a) and Irreplaceability.org (2025) listed as threatened 11 terrestrial mammalian species, 5 amphibians, 10 avifauna. Marine mammals and reptiles have 7 dolphin species, 4 whale species, one dugong and 3 sea turtle species. The threatened category ranges from critically endangered (CR) to Data Deficient (DD – but still threatened). The dolphins were mostly recorded at the east side of the Municipality of Taytay which is outside of the MSPLS. However, the survey also was conducted at the Outer Sound of the MSPLS at the entrance of the Malampaya Sound (Bgy Tumbod, Taytay) where sightings of these animals were also reported.

Prominent among the marine mammals is the Irrawaddy Dolphin observed to be in the Inner Sound while the Bottlenose Dolphin was observed in the Outer Sound (MSPLS GMP, 2019). However, no recent literature (2020 – 2024) has reported sightings of the other mentioned dolphin species inside the MSPLS. These include also the Cetacean (whale) species. No recent reported sightings, however does not mean that the marine mammals are extinct in the area. Given their wide range of distribution and saltatory nature, the animals may come around at any time.

The Sperm Whale and the Killer Whale were also recorded. Unfortunately, the whales (Sperm Whale – either Dwarf or Pygmy; Killer Whale – Pygmy) were not specifically identified. However, their conservation status remains as least concern (LC) under the IUCN Red List (2025).

Terrestrial threatened species in the MSPLS are mostly endemics and there are 11 mammalian species, 5 amphibians, and 10 avifauna identified (Irreplaceability.org accessed in May, 2025). Endemic to the Palawan Province, but still found inside the MSPLS are the Palawan Bearded Pig, the Northern Palawan Tree Squirrel, The Palawan Stink Badger and the Palawan Flying Fox, to name a few. The complete list is found in 4.C.7.

The sea turtles (Green Turtle, Hawksbill Turtle and the Olive Ridley Turtle) were recorded in the western side of the MSPLS facing the West Philippine Sea where they have their nesting sites (MSPLS GMP 2019; PCSDS 2006b). They are sometimes sighted inside the Outer Sound above coral reefs and seagrass beds. PCSDS (2006a) recommended these areas as core zones for conservation in 2006 and the PAMO / PAMB have designated the western side as the Sea Turtle Conservation Zone (MSPLS GMP 2019). One sea turtle, the Loggerhead Turtle, has been sighted in 2006 but this species is rarely seen since then (PCSDS, 2006a, 2006b).

Mangrove species have been protected in Palawan since PD 705 and its protection have been strengthened by R.A. 7611, the Strategic Environmental Plan for Palawan Act, in June 1992 (Section 7). As such, many true mangrove species have been categorized by the IUCN Red List (2025) as threatened but of least concern (see list in Annex 4). Two species of note are Tabau (*Lumnitzera littoralis*), which is Critically Endangered (IUCN Red List, 2025), and the Gapas Gapas (*Camptostemon philippinensis*), which is of Endangered status (IUCN Red List, 2025). The former can be found in mangrove ecosystems in both Taytay and San Vicente areas of the MSPLS, while the latter can only be found in the Taytay mangrove areas of the MSPLS.

Priority Transboundary Biodiversity Issues

Threats/Risks and Issues

Bio-physical and social threats, issues and concerns are related to the management of the MSPLS. Transboundary biodiversity issues focus more on biological and to some degree, physical concerns. However, physical concerns are manifestations of anthropogenic causes that plague the MSPLS.

Priority transboundary issues are the conservation status of marine mammals and reptiles that are found in the MSPLS. They migrate all over the SCS and the GoT, especially the marine turtles, which are threatened species identified by the RedList 2025 of IUCN, and they are inadequately protected by the countries bordering the GoT and the SCS. These turtles are the Hawksbill Turtle, Green Turtle, the Olive Ridley Turtle, and as rare sightings but nevertheless present, the Loggerhead Turtle. The Hawksbill is critically endangered, whereas the Green Turtle is endangered. The other turtles are classified as vulnerable.

For marine mammals (cetaceans), the Irrawaddy Dolphin has a small population residing in the Inner Sound of the MSPLS and they are classified as endangered (PAMP 2025-20340; IUCN Red List 2025). However, the species can also be found in the Irrawaddy Estuary in Myanmar and some small populations in Southeast Asia. Hence, the Irrawaddy Dolphins are considered as of global importance. Due to their small populations around the GoT and the SCS, particularly in the MSPLS, they are threatened with extinction due to habitat destruction and as by-catch / accidental catch by fisherfolks (Tara Sayuki Whitty, 2015).

Other cetaceans found in the MSPLS but nevertheless threatened, although of least concern, are the Risso Dolphin, the Bottlenose Dolphin, the Pantropical Spotted Dolphin, Fraser's Dolphin and the Risso Dolphin. They are found in offshore zones at the entrance to the Malampaya Sound and in the western offshore zones of the MSPLS. Sighting in the same offshore zones are the whale species such as the Pygmy Killer Whales, the Dwarf Sperm Whale, the Short-finned Pilot Whale and the Melon-Headed Whale. As migratory species, they appear seasonally within the MSPLS.

Trend Analysis

Cited by Ancog, et.al (undated), Garcia et.al (2014), Nickerson (1999) and Long and Giri (2011) estimated that the Philippine mangroves have about 450,000 – 500,000 ha in the early 1920s and by 2000, only 256,185 ha remain. The last 75 years saw the escalation of mangrove deforestation. Approximately 337,000 ha or at least 75% of mangrove habitats have been lost due to conversion into brackish-water fishponds, timber harvesting for building materials, and coastal development which happened mostly in 1950s-1990. However, Ancog et.al (undated) cited Garcia et.al in 2014 found that despite the decrease in the total area of the mangroves through the decades, there has been an increase in the late 1990s and early 2000s. Mangroves in Palawan and particularly in the MSPSL have similar trends.

The different risks and threats within the PA are reflected on a map in Figure 4.C.5 below (PAMP, 2025-2034).

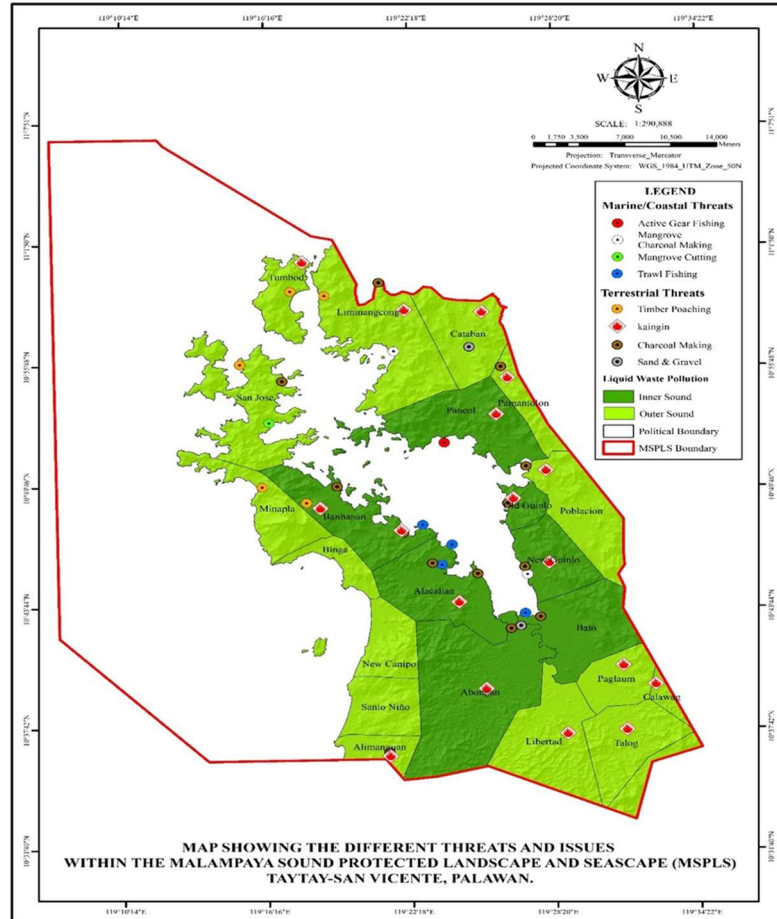


Figure 4.C.5. Sources and locations of different threats and issues within the MSPLS (PAMP, 2025-2034).

Fishery Resource.

From 1960s to the present, the Malampaya Sound has been a thriving traditional fishing ground so much so that it has been named as the “fishbowl” of the Philippines. As such, fishing pressure and other anthropogenic factors such as tourism and pollution loading have brought about much stress on the ecology of the MSPLS causing damage to corals, seagrass beds, mangroves and other marine life (McNeely et al. 1990; Deocadez and Aliño 2005 cited by Vicente 2024). This can permanently impact ecological timelines when combined with changing climate conditions due to rising atmospheric carbon dioxide (Bindoff et al. 2005; Doney et al. 2012; Doney et al. 2016 cited by Vicente 2024). More than 156 species of fish are found in the Sound of which 60 species are considered to be first class species with high commercial value (MSPLS GMP 2019). By 2024, there were already 262 species of fish identified (Vicente 2024). However, literature did not state whether this was due to habitat improvement or due to more intensive survey.

Biodiversity.

The degrading ecological conditions of Malampaya Sound, mainly due to anthropogenic activities, led to a decline in biodiversity and habitat quality. As a result, it negatively impacts the productivity and sustainability of its fishery resources by reducing fish stocks and altering species composition. In effect, it decreases economic opportunities for local fishing communities. The implementation of applicable conservation measures and restoration activities is vital to achieving ecological resilience and sustainable fisheries (Vicente, 2024).

Table 4.C.3 lists the issues and challenges faced by Malampaya Sound, as identified by various authors through the years (1995 – 2025).

Table 4.C.3. Trending Issues and challenges faced by Malampaya Sound, 1995 – 2025.

Threats and Issues	1995	1996	2003	2006	2009	2015	2015a	2017	2025
Terrestrial Development (Occupation of easement area*)									
Population Increase (Occupation of easement area*)									
Overexploitation									
Resource Conflict (use & access) [Occupation of easement area*]									
Habitat Destruction (timber poaching*)									
Pollution									
Cyanide & Dynamite Fishing (unsustainable fishing*)									
Illegal Fishing (unsustainable fishing*)									
Organic Matter & Nutrient Loading									
Poor Waste Disposal & Management (waste discharge/marine debris*)									
High Export of Fish Supply									
Climate Change (natural hazards: storm surge/strong typhoons*)									
Harmful algal blooms (HABs)/Red tide*									

Coral bleaching / Crown of thorns infestation*										
Oil slick / oil sheen*										

Legend: ^aPido 1995; ^bSandalo 1996; ^cPilien & Walpole 2003; ^dDavid et al. 2009; ^eAvillanosa et al. 2006; ^fCHE-UPLB 2015; ^gDela Pena et al. 2015a; ^hGonzales et al. 2017, ⁱPAMP 2025-2034 (Vicente 2024; ^{*}PAMP 2025-2034)

Many of these problems are interrelated and that one problem leads to another. For example, the high demand for fish in the export market and the growing population led to the use of illegal and harmful fishing techniques, which caused habitat destruction and overfishing.

Pollution.

Threats to endangered species are plastic pollution, which has been recently identified in 2015 (CHE UPLB 2015 as cited by Vicente 2024) and up to the present.^[2] Plastics from land sources find their way to rivers and eventually into the sea. Worse, they are being transported by ocean currents into the SCS, where the plastics affect the marine turtles and the cetaceans, sometimes leading to their deaths when ingested.

Land-based activities such as poor waste disposal and agri-chemicals run-off find its way to the Sound. Added to this is the sedimentation which was measured by Sombrito et al. in 2004 having ranges from 0.2 to 4 cm per year. David et al. (2009), cited by Vicente 2024, also found that the silt in the Sound is mainly siliciclastics, indicating a terrestrial-dominated source. They further emphasized that the slight increase in organic content in younger sediments reflects the rise in various anthropogenic inputs into the coastal region. The high total coliform concentration in the Sound could be attributed to household waste/ sewage and/ or effluent run-off, making it unsuitable for recreational purposes (Vicente, 2024).

Algal Blooms/Red Tide.

Algal blooms already frequently occur indicating eutrophication process is taking place (Sellner et al., 2003 cited by Vicente, 2024). Such events can result in massive fish kills and even mortality in humans due to the depletion of oxygen in the water and the toxins they release (McGowan, 2016 cited by Vicente 2024). According to Borja et al. (2000) and Sombrito et al. (2004), the cysts of *Pyrodinium* are responsible for causing harmful algal blooms.

Mangroves/Wetlands.

The mangroves in Malampaya Sound are among the finest in the country and are considered one of the Sound's most important resources. They are being cut for charcoal production, fuelwood, fish pen construction and housing materials. Some areas have been cleared and converted to fishponds or put to agricultural use. In 1985, satellite images showed that mangroves covered 2,500 ha. By 1998, there were fewer than 1,500 ha left. PSA, in 2020 cited by Vicente 2024, reported that the mangrove population has improved from 2,500 ha in 1985 to 3,342 ha in 2017. As of 2025, the total mangrove area is 3,338 has (PAMP, 2025-2034).

Hazards.

Anthropogenic activities reduce the ability of the Sound to recover from natural pressures like typhoons and diseases. This is evident in the current coverage of seagrass and coral, as discussed in the previous chapter. The declining fish catch and biodiversity in the area are causes for concern among the marginal fisherfolk. The rampant use of illegal and destructive fishing methods by non-resident fishers were perceived by respondents as the main cause

of habitat destruction (dela Peña et al., 2015). Immediate action is needed to address this issue and safeguard the livelihoods of the people who depend on fishing for their income and sustenance. Fishermen continue to experience a 60-80% reduction in catch (dela Peña et al. 2015b cited by Vicente, 2024).

Coral Reef and Seagrass.

The corals in the Sound have been observed to deteriorate over time. Banbanan, Liminangcong, and Tumbod coral reef are in poor condition due to the use of beach seine (baring) and turbid waters in the Inner Sound and to rampant use of Danish seine (hulbot-hulbot), sodium cyanide, and dynamite in fishing. However, the coral reefs in the Outer Sound in Bgys Banbanan and Liminangcong remain in good condition. At present, the coral reefs are in poor condition in the four selected MSPLS barangays in 2015 than previously reported as fair to good condition in 2006 (PCSDS, 2006a; Matillano et al., 2014; dela Peña et al., 2015b cited by Vicente, 2024).

In summary, as shown in Table 4.A.5, all identified threats and issues have converged by 2025 whereas there were only sporadic identification of threats and issues through the years since 1995. This indicates a trend that anthropogenic pressures have increased in the MSPLS and that management measures are not enough in mitigating them. This is exacerbated by climate change and natural hazards. The MSPLS management staff complement has not kept pace to the increase in threats. As such, innovative management approaches and strategies need to be done to face this challenge. The MSPLS was called the “fishbowl of the country” since the late 1990s up to present because it provides a substantial contribution to the country’s economy through the fishery sector (Vicente, 2024). Since then, degradation threatens its resources, much of it due to human causes. Conservation measures have been put in place including its declaration as a protected landscape and seascape in 2000. However, degradation continues to this day. Only the mangrove ecosystem has made improvements but only in selected areas. Seagrass and coral ecosystems are still in poor to fair conditions (Vicente, 2024).

Other threats, issues and concerns and recommendations are listed in Annex 4 as identified by the PAMP, 2025-2034.

Risk Assessment and Valuation of economic losses

The major sources of livelihood are fishing and farming. In Taytay, fishing is 39% and farming is 34%. In San Vicente, fishing is 48% and farming is 33%. While majority of local fishers use hook and line, fishing pressure in Malampaya Sound is critically high with a density of 23 fishers/km², thus, fishers are experiencing a 60-80% decrease in catch during the period 2012 – 2015 (dela Peña et al., 2015).

Other economic activities of the locals are trading, services and employment in the public and private sectors, manufacturing and construction, aquaculture, NTFP collection, agroforestry, mat weaving, rope making, furniture making, food processing, baskets, and boat making, bamboo/rattan plantation, bank/finance, resort operations and retail / sari-sari stores (MPDO Taytay, Socio-Economic Profile 2022; PAMP, 2025-2034). The total mangrove area of about 802 ha in the study site, of which only about 46% is in healthy condition, has fisheries value and direct economic revenue estimated at PhP 7.378 million (US\$ 184,460) and PhP 14.756 Million (US\$ 368,920), respectively (Dela Peña et al. 2015). As discussed above, resource use/extraction is a major concern, and the risk is high for resource degradation to happen. This, in turn, will place all the livelihood activities at risk since without the resource base, the livelihoods will not be successful.

Tourism in Taytay and San Vicente is being strengthened as an industry. At present, the activities in the area are mostly nature-based. Taytay’s rich biodiversity are both found underwater and in its terrestrial environs. Malampaya Sound is also famous for its Irrawaddy dolphins (*Orcaella brevirostris*), a critically endangered species found only in few remote places in Southeast Asia. Features in the four (4) barangays of San Vicente that are included

in MSPLS that have high potential for tourism activities are its beaches, landscape view on hilltops, dive sites and the transpiring surfing area at the Long Beach in Barangay Alimanguan (PAMP, 2025-2034). As to the risks in the tourism industry, the carrying capacity of the places where tourism is high, may be exceeded thus putting much pressure on the resources of the Sound. It may also disturb the nesting areas of the marine turtles and the feeding habits of the Dugongs.

Potential Impact/Risks of Natural Threats and Occurrences of Hazards

The following threats and hazards that have an impact on the biodiversity and natural resource of the PA were identified as follows (PAMP, 2025-2034):

1. Unsustainable Fishing;
2. Occupation of Easement Area;
3. Harmful Algal Blooms (HABS)/ Red Tide;
4. Coral Bleaching/ Crown of Thorns Infestation;
5. Waste Discharge/ Marine Debris;
6. Timber Poaching;
7. Oil Slick/Oil Sheen; and
8. Natural hazards: storm surge/strong typhoon

Most of the hazards identified are human induced except for natural occurrences such as strong typhoons, storm surge, coral bleaching and infestation of crown of thorns. The protected area being surrounded by the sea is prone to strong waves and typhoon. The houses, infrastructure and livelihood such as fish cages, baklad, green mussel culture, boats and gears are at risk to be affected/damaged by these natural events. Mobility of people, goods and services are affected due to road damage caused by these hazards (PAMP, 2025-2034). Typhoon Odette (internationally named “Rai”) in December 2021, left 89,782 houses damaged (PAMP, 2025-2034).

Rice farms in the low-lying areas of the PA are at risk of damage due to flooding in Barangay Abongan. This could put the food security of the municipality at high risk. On the other hand, drought also causes damages (PAMP, 2025-2034).

Climate change has caused corals to bleach and die. At risk due to this damage is the food security of the municipalities surrounding the MSPLS since coral reefs provide support to the local fishing livelihood of the communities and protect the shoreline against sea level rise, storm surges and strong waves. It also has been observed that the Crown of Thorns Starfish (CoT) have infested many coral reefs in the MSPLS. These may cause also the death of the corals (MSPLS’ Response Plan, 2023-2028).

Algal bloom, or red tide, events have been recorded in the past in the MSPLS and has direct impact on the shellfish harvest. This occurrence has put the green mussel culture of the coastal communities at risk and also a major health risk to humans that consume affected shellfish. The probability of repeat events is high (MSPLS’ Response Plan, 2023-2028).

In a FGD and validation workshop event as cited by Dela Peña in 2015, the participants identified weak enforcement of the ban on mangrove cutting as the main reason for its degradation in spite of the entire province of Palawan being declared as a national mangrove reserve. Mangroves in barangays Liminangcong, San Jose and Tumbod have fair mangrove condition. The workshop also considered charcoal production as the top threat to mangrove forests especially in six villages of Taytay (PCSDS, 2006b). The Philippine National Police plant 100 seedlings of mangroves in Tumbod every month since October 2012 making it an indication of reforestation efforts, cited in the same workshop (dela Peña, 2015 cited in MSPLS PAMP, 2025-2034).

Interviews were conducted in 2015 (MSPLS PAMP 2025-2034). Of the 64 validated responses from 113 households, the biggest perceived threat to mangroves in the study site is wood harvesting for charcoal making (68.8%) since 93.8% of 113 households interviewed use wood and charcoal as fuel for cooking. Natural causes and pollution are the least perceived threats to mangrove habitat. Destructive fishing method such as the use of dynamite, sodium cyanide, and Danish seine (hulbot-hulbot) have generally caused the poor condition of coral reefs in the four selected MSPLS barangays in Taytay. These illegal and destructive fishing methods have been in existence for a long time and still continue to this day. This is confirmed by 86% of household respondents who indicated that the primary threat to their coral reefs is illegal and destructive fishing methods. No single huge threat is evident for seagrass beds (dela Pena et al., 2015). Table 4.E.4 below summarizes the resource management issues in MSPLS.

Table 4.C.4. Summary of fishery-related resource management issues in Malampaya Sound, Taytay, Palawan, Philippines (dela Peña et al., 2015 cited in MSPLS PAMP, 2025-2034).

Category of Issues	Mangrove	Seagrass	Corals
Resource Use	<ul style="list-style-type: none"> • Cutting of mangroves for charcoal/repair of house • Presence of plastic garbage 	Presence of plastic garbage	<ul style="list-style-type: none"> • Except in Banbanan, the use of dynamite, sodium cyanide, and Danish seine (hulbot-hulbot) are present in 3 MSPLS barangays • In Liminangcong, scarelines of Danish seine (hulbot-hulbot) are reportedly left in coral reefs
Resource access			<ul style="list-style-type: none"> • Non-resident fishers (Batangas, Manila and Cebu) using Danish seines have caused huge damage to coral reefs in Liminangcong, Tumbod, and San Jose • These Danish seines are reportedly operators having local partners

Current Management and Institutions

a. Policy & Institutional Framework

Malampaya Sound Protected Landscape and Seascape (MSPLS) was established as protected area under the National Integrated Protected Areas System (NIPAS) Act (RA 7586) on July 12, 2000 by virtue of Presidential Proclamation No. 324 signed by President Joseph Estrada on July 12, 2000. It covers a total area of 200,115 comprised of 88,776 hectares of land and 111,339 hectares of water (Figure 4.C.1). The protected area covers 22 barangays of which 18 are under the administrative jurisdiction of Taytay and 4 are under San Vicente (MSPLS General Management Plan, 2019 and PAMP, 2025-2034).

The multi-sectoral PAMB is responsible for deciding policies, the development, implementation and reviewing the GMP programs for the area. The PAMB ensures that communications with outside organizations are maintained so that their policies are acknowledged and implemented by other agencies. Projects and programs that affect the environment are evaluated and approved by the PAMB (MSPLS GMP, 2019). The PAMB also seeks to generate fees for the area through charging for the use of resources such as irrigation canals, rice mills, dryers, timber, rattan, marine resources and products that are marketed outside of the protected area boundary. It will continue to seek grants and other means to ensure the programs can be sustained financially (MSPLS GMP, 2019). Skills development for PAMB members and PAO staff needs to be provided to enhance and strengthen capabilities in PA management (MSPLS GMP, 2019).

b. Protection Status

As provided in the ENIPAS Act of 2018, the Protected Area Management Board (PAMB) will be responsible for the overall implementation of the management plan. At present, there are 37 PAMB members duly appointed by the DENR Secretary (MSPLS PAMP, 2025-2034).

The Protected Area has the following stakeholder’s group who plays a crucial role in the protection, management and sustainable utilization of the natural resource of Malampaya Sound Protected Landscape and Seascape (MSPLS PAMP, 2025-2034).

Table 4.C.5. Stakeholders in the MSPLS (PAMP, 2025-2034)

Stakeholders’ Group of MSPLS	Representatives
Community Level	Senior Citizens, Indigenous People, Youth, Women, Fisherfolks, Farmers
Barangay Officials	Leaders of the local community, Eighteen (18) Barangays in Taytay and Four (4) Barangays in San Vicente
Municipal, Provincial, and National Government	Municipal Agriculturist Office (MAO), Municipal Environment and Natural Resources Office (MENRO), Municipal Planning and Development Office (MPDO), Municipal Tourism Office (MTO), Bureau of Fisheries and Aquatic Resources (BFAR), Palawan Council for Sustainable Development Staff (PCSDS)
Community-based organizations and NGOs with environmental related projects and programs	Malampaya Foundation Inc. (MFI), World Wildlife Fund (WWF), Peoples’ Organizations
Private Sector	Business managers, the work force and their representatives involved in particular economic activities such as water supply, communication, fisheries and tourism
Academe	Department of Education, Western Philippines University (WPU), researchers
Enforcement Agencies	Philippine Coast Guard (PCG), Philippine National Police (PNP), PNP-Maritime, Philippine Navy (WESCOM), Bantay-Dagat and Bantay Gubat
Resource Managers	Protected Area managers, planners and management staff (PAMO), DENR, NGOs, PCSDS

c. Institution (MSPLS PAMP, 2025-2034)

The Protected Area Management Office (PAMO) headed by the Protected Area Superintendent presently works in the area. As of June 2024, total PAMO staffing is 13 with 11 contractual staff and two detailed by DENR (MSPLS PAMP, 2025-2034).

Table 4.C.6. Current Park Management Office (PAMO) Manpower (PAMO-MSPLS, 2024)

Position	Contractual	DENR detailed	Total
Protected Area Superintendent		1	
Administrative Assistant	2		
Office Support Staff	1		

Coastal and Marine Ecosystem Management Program Extension Officer	1		
Data Encoder	1		
Forest Ranger		1	
Park Rangers	5		
Janitor	1		
TOTAL	11	2	13

Four (4) units support the PASu; marine protection, forest protection, IEC and planning. An administrative and finance unit of the PENRO provides auxiliary services (PAMP 2025-2034). The current deployment consists of six (6) staff. Six rangers are currently deployed in the proposed land area totaling 88,776 hectares. If the current deployment rate is used, present ration is one marine ranger for every 22,514 hectares of marine waters and one forest ranger for every 17,647 hectares of land forests (MSPLS PAMP, 2025-2034).

The Park Management Office located at Barangay Old Guinlo has the following logistical equipment for its day-to-day operation: one (1) speed boat with t5hp engine, two (2) units of desktop computers, three (3) printers, three (3) laptops. The office is installed with five (5) CCTV cameras. Mobile phone devices are used in carrying out official communication and as well as multimedia tool in checking emails, photo documentation and social media updates (MSPLS PAMP, 2025-2034).

Management Constraints (MSPLS PAMP, 2025-2034)

- Inadequate fund allocation to financially support the day-to-day activities and field operation of the PA.
- Understaffed and lack of technical manpower needed in the assessment and monitoring of the resources within MSPLS.
- Insufficient logistics in carrying out activities for marine and land patrolling operations.
- Lack of sustainable financing for the implementation of MSPLS plans and programs.
- Weak support from the enforcement agencies when requesting for assistance in various apprehension scenarios conducted by the PAMO.

Gaps and Priority Challenges

As discussed in the report, Ancog et.al (undated) reported in their study of the Wetland Park in Manila Bay that the mudflats and tidal flats are poorly studied and as such information about them are found wanting. As in the case of the MSPLS, the same finding holds true.

Vicente, in 2024, conducted a study on the MSPLS by researching online scientific journals pertaining to MSPLS. His probe revealed that there have been very few studies conducted on Malampaya Sound. Only an average of 2 articles every year were published in scientific journals. These are mainly related to biodiversity, coastal resource management, geology, and aquaculture. In short, there is a scarcity of information on the MSPLS (Vicente, 2024).

With respect to the tourism sector, sites for cultural interactions with local communities are yet to be identified by the Municipal Tourism Office. Eco-tourism activities in the Malampaya Sound Protected Land and Seascape (MSPLS) are yet to be firmed up to ensure that visitor and tourist management’s end goal is for the conservation and protection of the natural resource of the PA (MSPLS PAMP, 2025-2034).

Priority Challenges

Securing the locals' support requires a great deal of effort and determination for the PA management because people want higher productivity in their core economic activities. With the realization of dwindling resources, its limit and capacity, stakeholders became more involved in resource management and intends to have a stake in the outcome of conservation work within the PA (MSPLS PAMP 2025-2034). The local communities aspire to improve their standard of living.

The Malampaya Sound boasts a rich and diverse ecosystem. However, it is threatened by destruction due to human-made disturbances such as poor waste disposal, high sedimentation rate, high coliform concentration, terrestrial development, habitat destruction, pollution, illegal fishing, and overexploitation. While protective measures have been in place since the 1970s, more work is needed to achieve sustainable use of the area. The seagrass and coral cover in the area is still in poor to fair condition, indicating the need for urgent action to protect them (Vicente, 2024).

The preservation of Malampaya Sound is only achievable through the collaboration and cooperation of the academic community, government agencies, non-government organizations, and the local community. The protection of this ecosystem requires a joint effort from all stakeholders to ensure a sustainable future for the Sound and the surrounding environment. Community involvement and empowerment, income diversification of the locals, strict enforcement of existing laws, monitoring of environmental parameters, and implementation of sustainable fishing practices is required to ensure long-term sustainability of marine resources (Vicente, 2024).

In summary, the priority challenges are:

- Seeking funding to conduct biodiversity studies and assessments in mudflats and tidal flats
- The need to bolster community involvement in resource management planning, decision making, policy formulation, and implementation.
- The LGUs need to prioritize interventions to address the growing population (i.e high in-migration rate) that puts greater pressure in the utilization of natural resources in both municipalities.
- The need for more effective enforcement and implementation of existing laws within the Protected Area.
- Address limited knowledge and capabilities in resource management
- The need to bolster technical and financial support from LGUs.
- A more effective resource management and less organizational politics locally and within the region.
- Improve people's limited access to basic needs such as food, shelter, healthcare education and employment.

Coastal Wetlands

Table 4.C.7 MSPLS List of Threatened Species

Mammals

Scientific Name	Common Name	Family	Order	UCN Red List	Population Trend	Distribution (Km ²)	overlap	Rank / Number
<i>Sundasciurus juvenicus</i>	Northern Palawan Tree Squirrel	Sciuridae	Rodentia	LC	stable	7,784	11.1	3/4
<i>Sus ahoenobarbus</i>	Palawan Bearded Pig	Suidae	Cetartiodactyla	VU	decreasing	10,538	8.4	3/4
<i>Hylopetes nigripes</i>	Palawan Flying Squirrel	Sciuridae	Rodentia	NT	decreasing	11,505	7.5	3/4

<i>Crocidura palawanensis</i>	Palawan Shrew	Soricidae	Eulipotyphla	LC	unknown	11,807	7.3	3/4
<i>Hystrix pumila</i>	Philippine Porcupine	Hystricidae	Rodentia	VU	decreasing	12,398	7.0	3/4
<i>Mydaus marchei</i>	Palawan Stink Badger	Mephitidae	Carnivora	LC	unknown	12,447	6.9	3/4
<i>Acerodon leucotis</i>	Palawan Flyng Fox	Pteropodidae	Chiroptera	VU	decreasing	12,751	6.8	3/17
<i>Manis culionensis</i>	Philippine Pangolin	Manidae	Pholidota	NT	decreasing	12,895	6.7	3/4
<i>Maxomys panglima</i>	Palawan Maxomys	Muridae	Rodentia	LC	stable	13,144	6.6	3/4
<i>Tupaia palawanensis</i>	Palawan Tree Shrew	Tupauidae	Scandentia	LC	stable	13,168	6.6	3/4
<i>Chiropodimys calamianensis</i>	Palawan Pencil-Tailed Tree Mouse	Muridae	Rodentia	DD	unknown	14,052	6.3	3/4

Legend: EN – Endangered; VU – Vulnerable; LC – Least Concern; DD – Data Deficient; NT – Near Threatened

Source: <https://irreplaceability.cefe.cnrs.fr/sites/14753> accessed 19 March 2025

Amphibians

Scientific Name	Common Name	Family	Order	UCN Red List	Population Trend	Distribution (Km ²)	% overlap	Rank / Number
<i>Megophrys ligayae</i>	Palawan Horned Frog	Megophryidae	Anura	EN	Decreasing	1930	12.5	3/5
<i>Barbourula busuangensis</i>	Philippine Flat-Headed Frog	Bombinatoridae	Anura	VU	Decreasing	2668	7.8	3/4
<i>Ingerophrynus philippinicus</i>	Philippine Toad	Bufo	Anura	LC	Stable	13,477	6.4	3/4
<i>Sanguirana sanguinea</i>	NA	Ranidae	Anura	LC	Stable	15,214	5.7	4/5

Legend: EN – Endangered; VU – Vulnerable; LC – Least Concern

Source: <https://irreplaceability.cefe.cnrs.fr/sites/14753> accessed 19 March 2025

Birds

Scientific Name	Common Name	Family	Order	IUCN Red List	Population Trend	Distribution (Km ²)	% overlap	Rank / Number
<i>Ptilocichla falcata</i>	Falcated Wren-Babbler	Timaliidae	Passeriformes	VU	Decreasing	6,001	14.4	3/4
<i>Otus fuliginosus</i>	Palawan Scops Owl	Strigidae	Strigiformes	NT	Decreasing	8,607	10.0	3/3
<i>Cyornis lemprieri</i>	Palawan Blue Flycatcher	Muscicapidae	Passeriformes	NT	Decreasing	10,986	7.9	3/4
<i>Polyplectron napoleonis</i>	Palawan Peacock Pheasant	Phasianidae	Galliformes	VU	Decreasing	11,489	7.5	3/4
<i>Ficedula platenae</i>	Palawan Flycatcher	Muscicapidae	Passeriformes	VU	Decreasing	11,491	7.5	3/4
<i>Ixos palawanensis</i>	Sulphur-Bellied Bulbul	Pycnonotidae	Passeriformes	LC	Decreasing	11,493	7.5	3/4
<i>Malacocincla cinereiceps</i>	Ashy-Headed Babbler	Timaliidae	Passeriformes	LC	Decreasing	12,143	7.1	3/4

<i>Aethopyga shelleyi</i>	Lovely Sunbird	Nectariniidae	Passeriformes	LC	Stable	13,485	6.4	3/4
<i>Copsychus niger</i>	White-Vented Shama	Muscicapidae	Passeriformes	LC	Decreasing	13,693	6.3	3/4
<i>Parus amabilis</i>	Palawan Tit	Paridae	Passeriformes	NT	Decreasing	14,312	6.2	3/4

Legend: EN – Endangered; VU – Vulnerable; LC – Least Concern; NT – Near Threatened

Source: <https://irreplaceability.cefe.cnrs.fr/sites/14753> accessed 19 March 2025

Marine Mammals and Reptiles in MSPLS

Scientific Name	Common Name	Family	Order	IUCN Red List	Population Trend	Observation / Presence	REMARKS
<i>Orcaella brevirostris</i>	Irrawaddy Dolphin	Delphinidae	Artiodactyla	EN	decreasing	Inner Sound	Mostly found in the Inner Sound
<i>Tursiops truncatus</i>	Bottle-Nosed Dolphin	Delphinidae	Artiodactyla	LC	unknown	Outer Sound	Commonly sighted in Taytay East
<i>Stenella longirostris</i>	Spinner Dolphin	Delphinidae	Artiodactyla	LC	unknown	Outer Sound	Commonly sighted in Taytay East
<i>Stenella attenuata</i>	Pantropical Spotted Dolphin	Delphinidae	Artiodactyla	LC	unknown	Outer Sound	Commonly sighted in Taytay East
<i>Lagenodelphis hosei</i>	Fraser's Dolphin	Delphinidae	Artiodactyla	LC	Unknown	Outer Sound	Commonly sighted in Taytay East
<i>Grampus griseus</i>	Risso's Dolphin	Delphinidae	Artiodactyla	LC	Unknown	Outer Sound	Commonly sighted in Taytay East
<i>Steno bredanensis</i>	Rough-toothed Dolphin	Delphinidae	Artiodactyla	LC	Decreasing	Outer Sound; Offshore West	Commonly sighted in Taytay East
<i>Peponocephala electra</i>	Melon-headed Whale	Delphinidae	Cetacea	LC	Unknown	Outer Sound; Offshore West	Commonly sighted in Taytay East
<i>Globicephala macrorhynchus</i>	Short-finned Pilot Whale	Delphinidae	Cetacea	LC	Unknown	Outer Sound; Offshore West	Commonly sighted in Taytay East
<i>Kogia sima</i> <i>Kogia breviceps</i>	Sperm Whale (Dwarf) (Pygmy)	Delphinidae	Cetacea	LC	Unknown	Outer Sound; Offshore West	Commonly sighted in Taytay East. Did not specify
<i>Feresa attenuata</i>	Killer Whale (Pygmy)	Delphinidae	Cetacea	LC	Unknown	Outer Sound; Offshore West	Commonly sighted in Taytay East. Did not specify
<i>Dugong dugon</i>	Dugong	Dugongidae	Sirenia	VU	Decreasing	Outer Sound	Among seagrass beds
<i>Chelonia mydas</i>	Green Turtle	Cheloniidae	Testudines	EN	decreasing	West side MSPLS Outer Sound	Nesting area in western MSPLS

<i>Eretmochelys imbricata</i>	Hawks Bill Turtle	Cheloniidae	Testudines	CR	Decreasing	Western MSPLS Outer Sound	Nesting area in western MSPLS
<i>Carreta carreta</i>	Loggerhead Turtle	Cheloniidae	Testudines	VU	decreasing	Outer Sound	Rarely seen
<i>Lepidochelys olivacea</i>	Olive Ridley Turtle	Chelodinae	Testudines	VU	Decreasing	Outer Sound	2 nd commonly seen next to the Hawksbill Turtle

Legend: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; LC – Least Concern

Source: PCSDS 2006 ECAN Report and IUCN REDLIST 2025

Table 4.C.8 List of Mangrove Species in MSPLS

Family Name	Scientific Name	Common Name	Taytay*	San Vicente**	Conservation Status***
True Mangrove					
Primulaceae	<i>Aegiceras floridum</i>	Tinduk-tindukan		×	NT
Primulaceae	<i>Aegiceras corniculatum</i>	Saging-saging	×		LC
Rhizophoraceae	<i>Bruguiera gymnorrhiza</i>	Busain	×	×	Common
Rhizophoraceae	<i>Bruguiera sexangula</i>	Pototan	×	×	LC
Rhizophoraceae	<i>Bruguiera cylindrica</i>	Pototan Lalaki	×	×	LC
Rhizophoraceae	<i>Bruguiera parviflora</i>	Langarai	×	×	LC
Rhizophoraceae	<i>Ceriops tagal</i>	Tangal	×	×	LC
Rhizophoraceae	<i>Ceriops decandra</i>	Malatangal	×	×	NT
Combretaceae	<i>Lumnitzera littorea</i>	Tabau	×	×	CR
Combretaceae	<i>Lumnitzera racemosa</i>	Kulasi	×	×	NT
Arecaceae	<i>Nypa fruticans</i>	Nipa	×	×	LC
Rhizophoraceae	<i>Rhizophora apiculata</i>	Bakauan Lalaki	×	×	LC
Rhizophoraceae	<i>Rhizophora mucronata</i>	Bakauan Babae	×	×	LC
Rhizophoraceae	<i>Rhizophora stylosa</i>	Bakauan Bato	×	×	LC
Lythraceae	<i>Sonneratia alba</i>	Pagatpat	×	×	LC
Lythraceae	<i>Sonneratia caseolaris</i>	Pedada	×	×	LC
Euphorbiaceae	<i>Excoecaria agallocha</i>	Buta Buta	×	×	LC
Meliaceae	<i>Xylocarpus granatum</i>	Tabigi	×	×	LC
Meliaceae	<i>Xylocarpus moluccensis</i>	Piag-au	×	×	LC
Malvaceae	<i>Camptostemon philippinensis</i>	Gapas-Gapas	×		EN
Mangrove Associate					
Acanthaceae	<i>Acanthus ebracteatus</i>	Tigbau	×	×	LC

Leguminosae	<i>Acacia farnesiana</i>	Aroma	×	×	Common
Pteridaceae	<i>Acrostichum aureum</i>	Lagolo	×	×	LC
Lecythidaceae	<i>Barringtonia asiatica</i>	Botong	×	×	LC
Lecythidaceae	<i>Barringtonia racemosa</i>	Putat	×	×	LC
Leguminosae	<i>Caesalpinia crista</i>	Sapinit	×	×	Common
Leguminosae	<i>Cynometra ramiflora</i>	Balitbitan	×	×	LC
Leguminosae	<i>Derris trifoliata</i>	Mangasin/ Derris	×	×	Common
Malvaceae	<i>Hibiscus tiliaceus</i>	Malubago/ Malibago	×	×	LC
Leguminosae	<i>Instia bijuga</i>	Ipil	×	×	Common
Rubiaceae	<i>Morinda citrifolia</i>	Bangkoro/ Apatot	×	×	LC
Myrtaceae	<i>Osbornia octodonta</i>	Tualis	×	×	LC
Pandanaceae	<i>Pandanus tectorius</i>	Prickly Pandan	×	×	LC
Leguminosae	<i>Pongamia pinnata</i> / <i>Milletia pinnata</i>	Bani	×	×	LC
Rubiaceae	<i>Scyphiphora hydrophyllacea</i>	Nilad	×	×	LC
Combretaceae	<i>Terminalia catappa</i>	Talisay	×	×	LC
Malvaceae	<i>Thespesia populneoides</i>	Malabanalo	×	×	Common
Malvaceae	<i>Thespesia populnea</i>	Banalo	×	×	LC
Apocynaceae	<i>Cerbera manghas</i>	Baraibai	×	×	LC
Bignoniaceae	<i>Dolichandrone spathacea</i>	Tui	×	×	LC

Legend: CR – Critically Endangered; EN – Endangered; LC – Least Concern; NT – Near Threatened.
Sources: *PCSDS 2006a, **PCSDS 2006b, ***IUCN RedList 2025

Breakdown:

- Total number of species surveyed (2006): 40
 - o Total number of True Mangrove species (2006): 20
 - o Total number of Mangrove associates (2006): 20
- Total number of Families (2006): 19
 - o Total number of True Mangrove families: 8
 - o Total number of families of Mangrove associates: 11

Table 4.C.9 MSPLS Threats, Issues, Concerns for Coastal Wetlands 2000 – 2025

2000 – 2006*	2007-2015**	2016 – 2025***	Recommendations‡
Mangroves / Coastal wetlands			
Conversion to fishpond; subject to cutting; Cutting and charcoal making are rampant	Habitat destruction due to wood harvesting for charcoal making & house repair	Timber poaching for house construction, building or repairing boats, furniture making, infrastructure, firewood & charcoal making • Severe to heavy siltation due to soil erosion	Programs for implementation include protection and sustainable management with enterprise development and support funds from government & private institutions • Apprehension, Filing of case, regular patrol and monitoring,

	<p>caused by mangrove degradation</p> <ul style="list-style-type: none"> • Mangrove cutting used for charcoal making and for construction of houses 		<p>establishment of Forest Product Monitoring Stations (FPMS), paralegal training, procurement of enforcement patrol and equipment</p> <ul style="list-style-type: none"> • Community organizing (CO) should be an integral part of the development and rehabilitation of mangrove areas, together with the other coastal resources • The local institutions should be developed and the capabilities of mangrove-dependent households should be strengthened and enhanced for them to become effective stewards and de facto managers of the resources. • The CBMFM/CBRMP concept of restoring the coastal resources may be adopted to generate local participation and to ensure the sustainability of whatever interventions implemented • Programs for implementation include protection and sustainable management with enterprise development and support funds from government & private institutions • Immediate rehabilitation and protection; Enrichment planting and assisted natural regeneration can be adapted to rehabilitate said areas using species distribution and zonation as among the bases for the choice of species. • Areas with clearings and developed but unproductive fishponds, abandoned and not covered with FLAs are proposed for aqua - silviculture applications.
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Seagrass			
<ul style="list-style-type: none"> • Re fish corrals and fish cages, no impacts are expected from the presence of these fishing structures on the seagrass ecosystems surveyed; • Continuous use of illegal fishing methods • Absence of sea cucumbers were observed in seagrass beds • Kaingin, cutting of mangroves threaten associated seagrass beds; • Siltation 	<p>Habitat destruction due to Illegal and destructive fishing methods</p>	<p>Damage to seagrass habitats</p>	<p>Programs for implementation include protection and enterprise development with support funds from government & private institutions</p>

- Indiscriminate throwing of garbage threatens seagrass beds;
- Pollution & extensive use of agrichemicals
- Declining water quality associated with eutrophication (nutrient loading), pollution from several forms of coastal development and destructive forms of fishing
- Sparse growth of seagrass in MSPLS

Corals

- | | | | |
|--|---|--|---|
| <ul style="list-style-type: none"> • Destructive fishing practices like use of dynamite and sodium cyanide • No sign of stress or discoloration associated with blast & cyanide fishing at time of survey • No coral bleaching event were observed at time of survey • Absence of Crown of Thorns in the coral reefs | <p>Habitat destruction due to Illegal and destructive fishing methods</p> | <ul style="list-style-type: none"> • Unsustainable fishing practices • Damage to coral reef • Coral bleaching • Crown of thorns (CoT) starfish infestation • Waste discharge and marine debris from terrestrial sources (includes solid wastes, agro-chemicals, siltation/ sedimentation) | <ul style="list-style-type: none"> • Programs for implementation include protection and enterprise development with support funds from government & private institutions • Address climate change issues • Bring back predators of CoT by controlling use of illegal fishing gears and unsustainable fishing practices; • Physical removal of CoT [existing program] and coastal clean-up • Research on probable effects & impacts; monitoring & assessment; Hydrological studies; |
|--|---|--|---|

Fishery

- | | | | |
|---|---|---|---|
| <p>Grouper populations relatively in good condition</p> | <ul style="list-style-type: none"> • Decline in fishery resources due to Illegal and destructive fishing methods • Fishing pressure | <ul style="list-style-type: none"> • Fish stocks threatened by increased demand for fish and seafood products; • Need for more efficient fishing methods; • inadequate management & enforcement; • lack of livelihood options • Use of destructive fishing methods • Increasing human demand for fish • Limited support from government • Unsustainable resource extraction practices, such as the use of fish mesh nets active gears (e.g. trawl fishing) • Electro-fishing, fish poisoning and blast fishing | <ul style="list-style-type: none"> • Programs for implementation include sustainable harvesting of fishery resources, enterprise development with support funds from government & private institutions • Training on alternative livelihood (seaweeds farming, abalone culture) [existing/ongoing] • Seaborne patrol & monitoring, • Impose regulation for sustainable fishing [ongoing] • Marine zoning [ongoing] • Management regimes such as: zoning, close season, protected areas, gear registration, use of pingers, etc are management options to regulate the fisheries in Malampaya Sound. |
|---|---|---|---|
-

- Intrusion of commercial fishers into the municipal waters
- Diminishing stocks/ populations of commercially important fish and invertebrates

Marine Mammals / Reptiles

- Sea turtles were observed swimming over coral reefs were observed at time of survey
- Declining population due to hunting for food (especially Dugong), by-catch / accidental capture, slow reproductive rate, dynamite & cyanide fishing
- Most available data are qualitative, extensive gaps in status, distribution, and behavioral characteristics;
- Quantitative data are deficient due to absence of research & monitoring
- Irrawaddy dolphin population is in immediate danger of extinction due to low numbers, limited range, and high mortality
- Conservation awareness is high among respondents
- Declining population of Irrawaddy Dolphins due to Illegal and destructive fishing methods
- Competition between Irrawaddy Dolphins' and fishers' food resource
- Contamination with pollutants and diseases, together with limited genetic diversity have all been identified as viable threats to Irrawaddy populations
- bycatch in local fisheries is the major threat to this population
- Declining food resource due to destructive fishing gears used
- Displacement of habitat for Irrawaddy Dolphin
- Mortalities of Irrawaddy dolphins
- bycatch in local fisheries is the major threat to this population
- In terms of Irrawaddy conservation and protection, the primary gear for regulation should be shrimp gillnet, followed by crab pots, crab gill net, bottom and surface gillnets for fish
- The death encountered by dolphin with fishing gears in the recent years (last 5 years) should be surveyed. An assessment of Irrawaddy Dolphin population (number) should be undertaken and compared to previous data
- The bottom line for Irrawaddy conservation is to keep the population number of the dolphin viable
- Management regimes such as: zoning, close season, protected areas, gear registration, use of pingers, etc are management options to conserve and protect the Irrawaddy Dolphin population and the environment of Malampaya Sound.

Others (covers terrestrial)

Recurring algal bloom affects mussel farms in Inner Sound due to climate change

- Land use & land classification are in conflict
 - Occupation of easement & waterways; Settlement within easement/salvage zone
 - High in-migration rate.
 - Displacement of coastal habitat, waste accumulation, flood and/or storm surge prone communities, salvage zone are occupied
 - Recurring Red Tide / algal bloom which have harmful effects on health (e.g., Paralytic Shellfish Poisoning & Diarrhetic Shellfish Poisoning)
 - Inventory of structures, census, Issuance of Notice of Violation, Boat and Fisherfolk Registration, Free Public Land Survey Program [existing / ongoing]
 - The LGUs need to prioritize interventions to address the growing population that puts greater pressure in the utilization of natural resources in both municipalities
 - Continuous monitoring activities
 - Continuous monitoring activities
 - IEC (Fisherfolks, Community People)
 - Campaigns on Organic Farming
 - Strict Implementation of existing National and Local Laws, Resolutions and Ordinances
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- Natural hazards: storm surge, flooding, typhoons resulting to scarcity / depletion of freshwater for domestic use due to natural hazards
 - Siltation and sedimentation from eroded roads
 - Sand and gravel extraction in rivers
 - Unregulated harvesting of marine resources
 - The increasing solid and liquid waste from waste generators such as household, industries, and motorboats. Poor solid waste management practices in the localities resulting to environmental and marine pollution in MSPLS
 - Unmonitored used of agro-industrial chemicals from agricultural fields that flows directly into the Sound affecting water quality and fish production
 - Presence of build-up and agricultural areas before declaration of the PA
 - Conversion of agricultural land into other non-agricultural uses
 - Salt water intrusion in agricultural lands
 - Limited knowledge and capabilities in resource management
 - Inadequate technical and financial support from LGUs
 - Inadequate fund allocation to financially support the day-to-day activities and field operation of the PA.
 - Lack of sustainable financing for the implementation of MSPLS plans and programs.
 - Resource management cannot be fully realized because of too much addressing Climate Change and Environmental Protection
 - CEPA on Environmental Protection
 - Mangrove and Tree planting (Reforestation)
 - Strict Implementation of existing national and local Laws, Resolutions and Ordinances addressing Climate Change and Environmental Protection
 - Thorough hazard characterization of MSPLS, to further substantiate the 2023 MSPLS Response Plan is essential to guide and aid resource managers in effectively managing critical natural and human resources of the area
 - Scientific studies on the impacts of climate change in the marine and coastal areas of MSPLS, in its forestry and agriculture; in the various species and natural areas of the PA; as well as health impacts through infectious diseases and air quality-respiratory should be undertaken in order to come-up with a climate change adaptation plan/measure for MSPLS.
 - Bolster community involvement in resource management planning, decision making, policy formulation, and implementation
-

organizational politics locally and within the region

- Understaffed and lack of technical manpower needed in the assessment and monitoring of the resources within MSPLS.
- Insufficient logistics in carrying out activities for marine and land patrolling operations.
- Weak support from the enforcement agencies when requesting for assistance in various apprehension scenarios conducted by the PAMO

Sources: *PCSDS 2006a&b; **Dela Pena et al. 2015, Malampaya Foundation 2015; ***Vicente 2024, PAMP2025-2034, MSPLS GMP 2019-2024, MSPLS Response Plan 2023-2028, Uchiyama et al. 2024, Gonzales et al. 2017, IUCN MMPATF 2022; ‡ all sources.

Table 4.C.10. Monitoring: Coordinates of Baseline Sampling for Taytay MSPLS in terms of coral cover (PCSDS, 2006)

Location	N latitude	E Longitude	Hard Coral Cover, % (2004 baseline)
Bgy Tumbod	10.58219	119.17500	31-50
Bgy Tumbod	10.58217	119.17498	31-50
Bgy Tumbod	10.58237	119.17501	31-50
Bgy Tumbod	10.58276	119.17498	31-50
Mabatingan Island	10.52446	119.19592	31-50
Mabatingan Island	10.52429	119.19549	31-50
Mabatingan Island	10.52427	119.19542	31-50
Mabatingan Island	10.52408	119.19506	31-50
Inner Bahura	10.49324	119.23479	31-50
Boat Rock	10.55239	119.20094	31-50
Boat Rock	10.55296	119.20102	31-50
Talisay Bay	10.56149	119.16423	51-75
Talisay Bay	10.56137	119.16379	51-75
Talisay Bay	10.56133	119.16373	51-75
Talisay Bay	10.56128	119.16324	51-75
Malapeña Island	10.55424	119.18438	51-75
Malapeña Island	10.55392	119.18443	51-75
Malapeña Island	10.55391	119.18445	51-75
Malapeña Island	10.55351	119.18493	51-75
Binaloan Bay	10.54423	119.20293	51-75
Binaloan Bay	10.54413	119.20247	51-75
Binaloan Bay	10.54413	119.20289	51-75
Binaloan Bay	10.54412	119.20355	51-75
Islang Mayaman	10.52175	119.18449	51-75

Islang Mayaman	10.52210	119.18407	51-75
Islang Mayaman	10.52212	119.18497	51-75
Islang Mayaman	10.52226	119.18407	51-75
Sapatos Island	10.50419	119.18297	51-75
Sapatos Island	10.50429	119.18271	51-75
Sapatos Island	10.52420	119.18270	51-75
Sapatos Island	10.50397	119.18271	51-75

Table 4.C.11. Monitoring: Coordinates of Baseline Sampling for Taytay MSPLS in terms of reef fishes.

Location	N latitude	E Longitude	Remarks (2004 baseline)
Sapatos Island	10 50 42.9	119 18 27.1	Low coral, high <i>C.teres</i> , 5m is sand
Mabatingan Island	10 52 40.8	119 19 50.6	High richness
Inner Bahura	10 49 32.4	119 23 47.9	Rocky rubble; low fish
Malapaña	10 55 35.1	119 18 44.6	High coral, high richness, low vis
Asugunan Pt. Talisay Bay	10 56 13.7	119 16 37.9	High coral; near Sound mouth; high vis; richness; turtle
Tumbod, Penabaltan Bay	10 58 21.9	119 17 50.0	High coral; near Sound mouth; high vis; richness; turtle
Boat Rock	10 55 29.6	119 20 10.2	Low vis; <i>Laticauda</i>
Mulawi, Binaloan	10 54 49.3	119 20 24.5	High DCA, high richness; near NPAP Guardhouse

Table 4.C.12. Monitoring: Coordinates of Baseline Sampling for Taytay MSPLS in terms of seagrass.

Location	N latitude	E Longitude	Approx Bed Width, in meters	Remarks (2004 baseline)
Bambanan (inner Sound) Malaya Bay	10 47 42.6	119 22 31.7	50	Mangroves as coastal vegetation
Liminangcong (outer Sound) Bucal	10 54 12.8	119 20 20.9	250	Shrubs, small trees as coastal vegetation

Table 4.C.13. Monitoring: Coordinates of Baseline Sampling for Taytay MSPLS in terms of Mangroves

Location	N latitude	E Longitude	Area, in sqm	Dominant Spp (2004 baseline)
So. Mayatan, Old Guinlo, bgy Guinlo			7000	Ct
So. Yakal, New Guinlo, Bgy Guinlo	10 49 33.8	119 27 26.1	3500	Ra & Rm
So. Ipil, Bgy Bato	10 44 30.7	119 27 25.1	4000	Rm
Bgy Bato			3750	Ra & Rm
Panikian, Abongan River	10 43 22.3	119 26 55.0	5500	Ra
So. Pinaggupitan, Abongan	10 42 48.9	119 26 28.5	4000	Bs, Xg
So. Inrea, Abongan River	10 12 54.4	119 22 25.1	3000	Xg
So. Tibay, Bgy Alacalian	10 43 33.5	119 25.7	3500	Ra & Rm
Bgy Alacalian	10 45 15	119 25 29.0	2500	Ra
Malampaya Maratpat Island, Alacalian, So. Kawakayan			2500	Ra
So. Maratdat, Bgy Alacalian	10 45.93 0	119 23.67 0	300	Rm & Ra
			5750	Rm & Ra

So. Lapay, Bgy Banbanan	10 50 56.9	119 16 52.3	2500	Ra
So. Sinyaran, Bgy Banbanan	10 48 42.2	119 19 50.5	3500	Ra & Bg
So. Turao, San Jose			1750	Rm & Ra
So. Turao, San Jose	10 52 12.5	119 15 47.4	2200	Ra & Rm
So. Pirate, San Jose	10 54 07.2	119 16 34.1	900	Ra
Tumbol Island	10 00 00.6	119 17 56.0	2550	Ra, Bg, Rm
Liminangcong Center	10 58 62.9	119 18 44.8	1000	Ra & Ct
So. Binaluan, Liminangcong	10 56 70.0	119 20 12.6	1500	Rm
So. Buluran, Bgy Binaluan	10 56 41.9	119 21 19.3	5000	Ra & Rm
So. Binaloan, Pancol	10 54 56.4	119 20 72.6	1000	Rm & Ra
So. Tulduan, Liminangcong	10 09 40.6	119 20 74.3	3500	Ra
Kataban River, Malampaya			6000	Rm & Ra
Pancol, Dibalat River			1500	Rm & Ra
So. Dibalat, Pancol	10 56 13.5	119 21 06.9	1680	Ra
So. Dimaabot, Pancol	10 50 49.3	119 26 31.9	6000	Ct

Legend: Ct- Ceriops tagal; Ra – Rhizophora apiculata; Rm – Rhizophora mucronate; Bg – Bruguiera gymnorrhiza; Xg – Xylocarpus granatum; Bs – Bruguiera sexangulare

Monitoring: Coordinates of Baseline Sampling for San Vicente MSPLS in terms of corals (PCSDS, 2006).

- Sampling sites for corals in San Vicente are Imuruan Island off New Canipo and Binga

Table 4.C.14. Monitoring: Coordinates of Baseline Sampling for San Vicente MSPLS in terms of Seagrass.

Location	N latitude	E Longitude	Approx Bed Width, in meters	Remarks (2004 baseline)
Bgy Binga	10.746730	119.330010	180 ± 20	Sand & rock substratum
New Canipo	10.716350	119.340050	260 ± 110	Fine sand
Imuruan Island	10.691 280	119.336250	100 ± 50	Sand
	10.700430	119.310740	25 ± 5	Sand

Table 4.C.15. Monitoring: Coordinates of Baseline Sampling for San Vicente MSPLS in Mangroves

Location	N latitude	E Longitude	Area, in sqm	Remarks (2004 baseline)
So. Lumambong, Binga	10 46 15.2	119 19 03.7	500	Sparse
So. Boding, Binga	10 44 05.2	119 20 36.3	600	Sparse
Bgy Alimanguan	10 36 56.4	119 19 24.6	3000	Sparse
Bgy Alimanguan	10 36 55.1	119 19 26.6	4500	Newly developed

RAMSAR Convention defines wetlands as “areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt, including areas of marine water shallower than six meters at low tide. This definition also encompasses riparian and coastal zones adjacent to wetlands, as well as islands or marine areas within the wetland, regardless of depth at low tide”.

Information obtained during the Inception Workshop of the TDA/SAP Project in Manila, 26-27 March 2025

Annex 4.D. Las Piñas–Parañaque Wetland Park (LPPWP) Write-up

Key Findings

- Despite the presence of anthropogenic disturbance and high degradation of the marine and coastal ecosystems of LPPWP and TMTP, both can still support a number of fish species.
- The key factor of success in mangrove rehabilitation / restoration was community involvement, making the community recognize the need to manage its natural resources such as the mangrove because of their dire local needs for fuel wood, and construction materials for building boats and houses (Garcia et.al, 2014).

Current Status by Ecosystem and by Indicator Group

Mangroves and Wetlands.

- The LPPWP represents a portion of the Manila de Bay and different ecosystem dynamics from open waters as it is in between two (2) tributaries, the Parañaque and Las Piñas River. Furthermore, the presence of mangroves creates mudflats that provide new habitats and resources for macrofauna to exploit.
- Mangrove area of 20.73 has (LPPWP); 23 mangrove species (ERDB report 2021); the *Avicennia marina* or Bungalow is the most abundant mangrove species with 68 trees occurring on the site. It is due to the presence of numerous mother trees, favorable environmental conditions, and continuous supply of fresh water from different rivers which facilitates its growth and survival.
- 30 has for TMTP; Several aquatic birds, both migratory and local, find food and shelter among the mangroves and the mudflats that develop during low tide. The earliest floral assessment done in TMTP was in 1996 as part of the Resource Ecological Assessment. They recorded a total of six (6) mangrove species which includes *Aegiceras corniculatum*, *Avicennia lanata*, *Avicennia marina*, *Avicennia officianallis*, *Nypa fruticans*, *Rhizophora mucaronata*, and *Sonneratia alba* (Aquino, 2022). A subsequent study was then done in 2005 wherein 16 mangrove species from nine (9) families were recorded (Gamido et al., 2015). The latest report on floral diversity of TMTP was done by DENR-NCR wherein the agency conducted a biodiversity assessment and monitoring in 2011. This was part of their study exploring the blue carbon stock potential of urban mangrove forests. The report recorded a total of 14 species from six (6) families of mangroves of which, the *Avicennia marina* was the most abundant species in the assemblage representing 94% of the total assemblage of mature mangroves (DENR-NCR, 2021). In terms of faunal diversity, the TMTP is an important habitat for migratory birds traversing the East Asian-Australasian Flyway and wetland birds. In 2012, the DENR-NCR recorded a total 12,242 **Coastal Biodiversity Assessment Report for LPPWP & TMTP** | 7 wetland and migratory birds of which, the agency recorded observations of the endangered Chinese Egret (*Egretta eulophotes*). Other endangered wetland bird species recorded in TMTP include the Black-face Spoonbill (*Platalea minor*), Far-eastern Curlew (*Numenius madagascariensis*), and Great Knot (*Calidris tenuirostris*). The 2011 DENR-NCR assessment also recorded species of Aphids, Coleopterans, Thomisidae, and Bivalves.
- A total of 67 species and 39 families were recorded in both sites composed of 56 species and 33 families of fish, six (6) species and two (2) families of crustaceans, and five (5) species and four (4) families of polychaetes.
- The Black Chin Tilapia (*Sarotherodon melanotheron*) and the Blue Swimmer Crab (*Portunus pelagicus*) are the most abundant species among the fish and crustacean capture assemblage.
- Results of this assessment may reinforce the establishment and identification of the extent of the LPPWP buffer zone pursuant to Section 8 of Republic Act 11038, in terms of ecological and economic criteria. The buffer zone will address the need to protect coastal species including below-water biodiversity associated

with mangroves and mudflats of LPPWP that may be at risk of exposure to pollution and other forms of disturbances.

- It also aims to come up with and recommend permanent monitoring plots for below-water coastal diversity in mangroves and mudflats of LPPWP and TMTP. This may complement the Biodiversity Assessment and Monitoring System (BAMS), which is an important decision-making tool in effective management of protected areas, by recommending additional methods to capture below-water **Coastal Biodiversity Assessment Report for LPPWP & TMTP** | 2diversity associated with mangroves, mudflats, and other wetland ecosystem types.
- technical report by Jensen (2018), about 90 species of waterbirds, or approximately 60% of the known population of waterbirds in the Philippines are found in Manila Bay. This includes species under threatened ecological status, with some even facing risk of extinction, that feed on fishes and invertebrates found on shallower waters of the Bay as well as in the intertidal mudflats.
- Deforestation of Philippine mangroves has been escalating during the last seventy-five (75) years. Approximately, 337000 hectares (75%) of mangrove habitats have been lost to brackish-water fishponds, timber harvesting for building materials, and coastal development which happened mostly in 1950-1990. To lessen the decline of mangrove habitats, several efforts have been implemented which are mostly afforestation, the earliest of which is in Bais Bay in the 1930s and Banacon, Bohol in the 1950s, intended primarily for wood supply and coastal protection against typhoons. The genus *Rhizophora* was almost exclusively used for afforestation efforts due to it can be handled more conveniently and may not require nursery culture before planting in flood-prone areas (Samson & Rollon, 2008).
- The long-term survival rate of the mangroves in rehabilitation programs is only at 10-20%. Two main reasons were cited on why it has a low survival rate: First is the favored species used for afforestation of mangroves, *Rhizophora* is planted in places unsuitable for its growth like the sandy substrates of exposed coastlines instead of the natural colonizers like *Avicennia* and *Sonneratia*. The second reason was mangroves were planted in places it has never existed before such as seagrass beds and tidal flats, for them to grow successfully, they should have been planted where fishponds were, where it was originally growing before it was repurposed for fishponds.

Discussion and Conclusions

Manila Bay is a large natural harbor in the Philippines, and it is surrounded by various ecosystems, including wetland habitats. Wetlands are important ecological features that provide various ecosystem services such as water filtration, flood control, habitat for diverse species, and carbon storage. In the context of Manila Bay, wetland ecosystems such as LPPWP play crucial roles to its ecology. For instance, mangrove forests in wetland habitats play a vital role in stabilizing shorelines, providing habitat for various marine and terrestrial species. Tidal flats, on the other hand, provide feeding and resting grounds for migratory birds and support a variety of small aquatic organisms. However, anthropogenic activities posed significant threats to both the ecological integrity of Manila de Bay and the wetland habitat of LPPWP.

Early estimations of the country's mangrove area have seen mangrove forests having approximately 450,000-500,000 ha in the early 1920s (Garcia et al., 2014; Nickerson, 1999) and a total area of 256,185 ha in 2000 (Long and Giri, 2011). Across the publication landscape, the reported values of mangrove forest areas have decreased; Looking at the figure presented by Garcia et al. (2014), there is a decrease in the total area followed by an increase in the late 1990s and early 2000s. In terms of value, Lagbas and Habito (2016), stated the overall value of mangroves in terms of fisheries, wood, and other values at approximately US\$ 84M per 140,000 hectares which translates to Php 28,942.9/ha. In another study, the value of mangroves in terms of their protective services was estimated at Php 193,000/ ha (Pelayo et al, 2018).

Due to the impending threat of climate change, regulating services provided by the mangroves has been more crucial now than ever, especially the buffering capacity against storms and flooding. Mangroves have the capacity to hold back and reduce wave forces with their extensive and dense above-ground roots. They provide a home to a wide variety of reptiles, amphibians, mammals, fish, crabs, shrimps, mollusks, and many other invertebrates. They also serve as nesting grounds for a variety of bird species. Due to the archipelagic nature of the country, more than half of the country's towns and villages depend on mangroves for food and other services they provide. As the country has been frequented by strong winds and storm surges brought about by typhoons, mangroves have been used as one of the strategies to protect the coastline.

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Priority Transboundary Biodiversity Issues

- Garbage from the communities in Canacao Bay, Bacoor Bay, Paranaque City and Las Piñas is due to the communities using the bays along the river as dumping ground, it gets pushed and deposited to the beaches of LPPWP through the sea water current. For this reason, a strict implementation of the Supreme Court decision regarding the management of Manila Bay particularly those provisions on pollution and garbage management. As defined by the Supreme Court, the Manila Bay Coordinating Office (MBCO) was recommended to strictly manage the Manila de Bay.
- The poor water quality of LPPWP can be attributed to being a catch basin to all wastes and pollutants from the inadequate management of wastes from domestic, commercial, and industrial activities and wastewater discharges from households, industries, and commercial and institutional establishments (ERDB, 2021). This is based on the secondary data gathered by the Environmental Management Services (EMS) of the National Capital Region (NCR) of the Department of Environment and Natural Resources (DENR) from 2010 to 2014 taken from the four sampling sites, namely: Paranaque River, Las Piñas River, and the north and south lagoons. According to the monitoring done, only the sea waters located on the north and northeastern and southeast and southwest part are considered highly vulnerable to pollutants coming from the 3 rivers while the low elevation areas including the beaches at the western side of the 2 islands are moderately vulnerable to pollutants.

Risk Assessment and Valuation of Economic Losses

- Economic value of fisheries based on two (2) scenarios, 350-meter and three (3) kilometer fishing ground radius, was at Php 521,821.00 and Php 3,055,707.00 respectively in LPPWP and Php800, 233.00 and Php4,686,047.00 respectively in TMTP.
- the economic value of the ecosystem services of the mangrove forest of LPPWP. In terms of direct benefits from ecosystem goods, mainly the wetland fish and marine resource production, the estimated total value of

marine products derived from the LPPWP ranges from PhP 245,129.62 to 26,730,962.61 (USD 4,426.84 – 479,079.56). In terms of the wetlands' direct use value as a recreational site using Travel Cost Method, the recreational value of LPPWP was estimated to be at PhP 949,381 (USD 16,930.27) per year.

- non-use value of the wetland through a contingent valuation method. Presenting a contingent scenario to each respondent, the annual willingness to pay of each household to support programs aimed for the preservation and protection of the wetland was estimated at PhP 1,003.32 (USD 18.05). Given this and the assumption that all households in the surveyed barangays will support and contribute from the proposed scenario, the annual value of the indirect benefits of the mangrove/wetland ecosystem of LPPWP was estimated at PhP 34,067,469.70 (USD 612,840.01) per year.

Current Management and Institutions

Gaps and Priority Challenges

- Currently, the BAMS for coastal and marine ecosystems only provides methods for the assessment and monitoring of mangrove habitats and does not include fauna as well as below-water species. It is essential to determine the underwater diversity in these ecosystems as it would provide further insights on the potential strategies for the conservation of mangrove stands and the coastal environment to further improve the services that these habitats provide.
- Information gaps with regards to the value of ecosystem services in LPPWP and TMTP hinders the formulation and implementation of policies and strategies that would protect the coastal ecosystems in these areas.

Recommended Priority Actions Including Regional Cooperation

- Baseline information and empirical data can be established that would address information gaps on the economic value of the ecosystems in LPPWP and TMTP as well as guidelines that would help decision-makers and other key stakeholders.

Annex 4.E. Summarized LPPWP per Indicator

Mangrove Area: 20.73 ha

Legal Status:

- Proclamation No. 1412 dated April 22, 2007 as critical habitat and ecotourism area
- eNIPAS Act 2019, as a national protected area
- RAMSAR Site

Bio-Physical Characteristics:

- Composed of 2 islands: Freedom Island and Long Island
- 23 species of mangroves in 14 taxonomic families
- 46 spp of birds in 25 families
- Macrobenthic assemblage – Phylum Annelida, Arthropoda, and Mollusca (most represented grp: in 9 families, 23 spp of bivalves, 10 families; 23 spp of gastropods)
- Wetland & migratory birds – 12,242
- 3 species of crustaceans (Portunidae family: mudcrabs and swim crabs); Gecarcinidae (Land crabs)
 - *Scylla serrata* (Alimango: most abundant species – Density of 61.4 individuals per hectare [74%])
 - *Portunus pelagicus* (Alimasag: 2nd most abundant species – Density of 21.8 (26%))
- Polychaetes: *Terebralia sulcata* (Sulcate Swamp Cerith) from the family Potamididae and *Perna viridis* (Asian Green Mussel) fam: Mytilidae

Table 4.E.1. Species composition and density of recorded macrofaunal and microbenthic species in the LPPWP.

Family	Scientific Name	English Name	Local Name	Density (indvl/ha)
Fish				
Ambassidae	<i>Ambassis gymnocephalus</i>	Bald Glassy	Langaray	0.2
Carangidae	<i>Caranx sp.</i>	Trevally/Jack	Talakitok	0.2
	<i>Selaroides leptolepis</i>	Yellow-stripe Scad	Salay Ginto	0.6
	<i>Scomberoides sp.</i>	Queenfish	Lapis	1.0
Cichlidae	<i>Sarotherodon melanotheron</i>	Blackchin Tilapia	Tilapia Arroyo	375.6
Dorosomatidae	<i>Sardinella sp.</i>	Sardinella	Tamban	0.2
	<i>Nematalosa nasus</i>	Bloch's Gizzard Shad	Kabasi	6.0
Elopidae	<i>Elops saurus</i>	Ladyfish	Berber	2.6
Gerridae	<i>Gerres filamentosus</i>	Whipfin Silver-Biddy	Malakapas	0.2
Gobiidae	<i>Amblygobius sp.</i>	Goby	Biya	0.4
Hemiramphidae	<i>Hemiramphus sp.</i>	Halfbeak	Sigwil	0.4
Leiognathidae	<i>Leignathus sp.</i>	Ponyfish	Sapsap	1.8
Megalopidae	<i>Megalops cyprinoides</i>	Indo Pacific Tarpon	Buwan-Buwan	0.8
Mugilidae	<i>Crenimugil seheli</i>	Blue Spot Mullet	Kapak	70.0
	<i>Mugil cephalus</i>	Flathead Grey Mullet	Banak	55.4
	<i>Ellochelon vaigiensis</i>	Squartail Mullet	Timbuker	0.6

Osfhronemidae	<i>Trichopodus trichopterus</i>	Three-spot Gourami	Gourami	0.8
Serranidae	<i>Epinephelus sp.</i>	Grouper	Lapu-Lapu	0.2
Terapontidae	<i>Pelates quadrilineatus</i>	Four-lined Terapon	Malabansi	1.0
Tetraodontidae	<i>Arothron sp.</i>	Puffer	Butete	0.2
Crustacean				
Portunidae	<i>Scylla serrata</i>	Mudcrab / mangrove crab	Alimango	61.4
	<i>Potunus pelagicus</i>	Blue crab / blue swimmer crab	Alimasag	21.8
Gecarcinidae	<i>Cardisoma carnifex</i>	Brown Land Crab	Kagang	0.2
Polychaetas				
Potamididae	<i>Terebralia sulcata</i>	Sulcate Swamp Cerith	Suso	
Mytilidae	<i>Perna viridis</i>	Asian Green Mussel	Tahong	

(Ancog et al., n.d.)

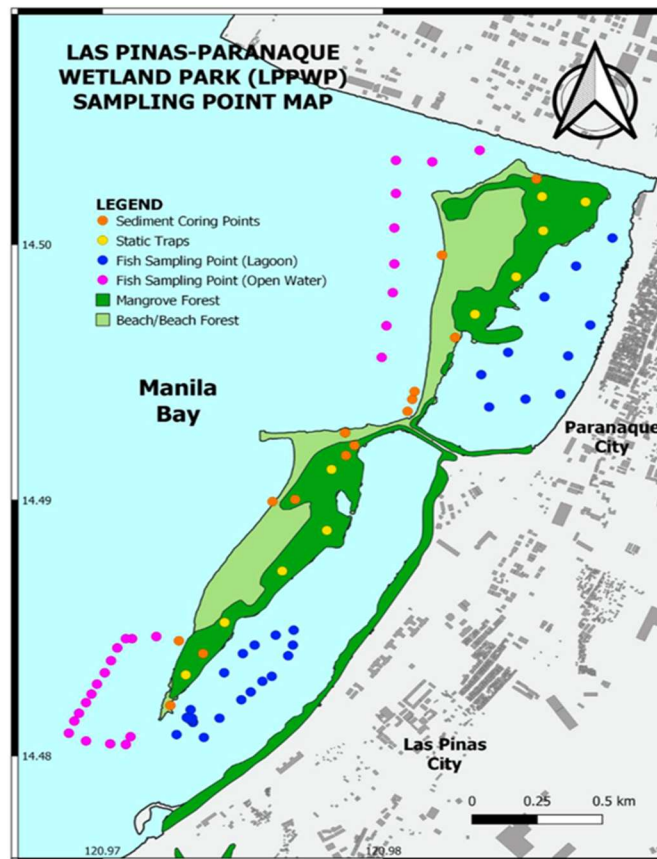


Figure 4.E.1. Map of fish sampling points, static traps, and sediment coring points for both lagoon and open water habitats in LPPWP

Threats:

- Four (4) reclamation projects are proposed / ongoing are next to the LPPWP
- Poor water quality – attributed to wastes and pollutants from the inadequate management of wastes from domestic, commercial, and industrial activities and wastewater discharges from households, industries, and commercial and institutional establishments

- Garbage deposition and pollution - only the sea waters located on the north and northeastern and southeast and southwest part are considered highly vulnerable to pollutants coming from the 3 rivers while the low elevation areas including the beaches at the western side of the 2 islands are moderately vulnerable to pollutants.
 - o Garbage from the communities in Canacao Bay, Bacoor Bay, Paranaque City and Las Piñas is due to the communities using the bays along the river as dumping ground, it gets pushed and deposited to the beaches of LPPWP through the sea water current
- Four capture methods used by communities – Gill Net (Tibog), Seine Net (Hatak / dala), Gill Net (Lambat), Nylon Net / Bamboo or Steel (Bubo)
- Geologic instability – erosion due to storm surge, tsunamis, typhoons, sea-level rise, flooding brought about by climate change

Annex 4.F. Summarized Tanza Marine Tree Park (TMTP) per Indicator

Mangrove Area: 30 has

Legal Status:

- In 2011, the Barangay Council of Tanza issued Ordinance No. 4, the first of its type in Metro Manila, designating the region as a "marine tree park" due to the presence of mangroves and migratory birds together.

Bio-Physical Characteristics:

- 14 mangrove species in 6 families- *Aegiceras corniculatum*, *Avicennia lanata*, *Avicennia marina*, *Avicennia officianallis*, *Nypa fruticans*, *Rhizophora mucaronata*, and *Sonneratia alba*
- *A.marina* is the most abundant representing 94% of the total mature mangroves
- Important area for migratory birds
 - o 12,242 migratory bird individuals
 - o Endangered species – Chinese Egret (*Egretta eulophotes*), Black-face Spoonbill (*Platalea minor*), Far-eastern Curlew (*Numenius madagascariensis*), and Great Knot (*Calidris tenuirostris*)
- Insect species – aphids, coleopterans, Thomisidae
- Bivalves

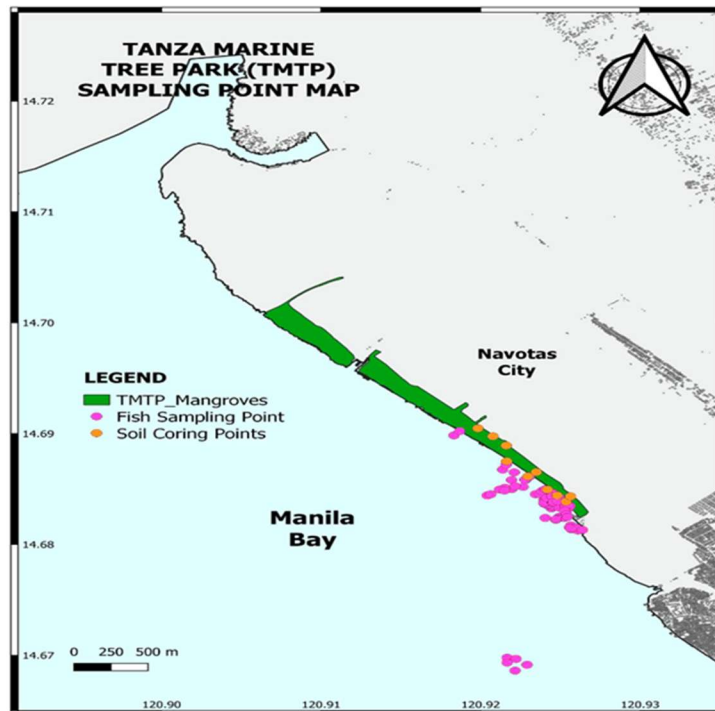


Figure 4.F.1 Map of fish sampling and sediment coring points along the open waters and within the mangrove forest of TMTP.

- Total of 57 species in 34 families recorded
 - o 52 fish species: 5 crustaceans
 - o Gobiidae (Goby) and Dorosomatidae (*Sardinella*, Shads, Lizardfish) were the most represented families among the captured fish assemblage with five (5) species each.

- o This was followed by the Ambassidae (Glassfish) with four (4) species, and Carangidae (Trevally, Jack & Queenfish), Leiognathidae (Ponyfish), and Platycephalidae (Flathead) have three (3) species representing each family.
- o *Sarotherodon melanotheron* was the most abundant species among the captured fish assemblage with D = 517.4 individuals per hectare (~39%). This was followed by *Crenimugil seheli* with D = 124.8 individuals per hectare (9%), *Ambassis gymnocephalus* locally known as Langaray with D = 96.9 individuals per hectare (7%), *Anodontostoma* sp. locally known as Talandi with D = 75.6 individuals per hectare (~6%), and *Chanos chanos* locally known as Bangus with D = 54.2 individuals per hectare (4%)
- o The Portunidae family (Mud Crabs & Swimmer Crabs) was the only family of crustaceans caught in TMTP and represented by five (5) species. Among these, *Portunus pelagicus* was the most abundant species among the captured crustacean species with D = 634 individuals per hectare (~92%). This was followed *Scylla serrata* with D = 34.5 individuals per hectare (5%) and an unidentified Mangrove Crab species, *Scylla* sp., locally known as Alimangong Bato with D = 19.7 individuals per hectare (~3%).
- o Recorded polychaetes during the macrobenthic sampling, four (4) species from four (4) families were captured. This includes *Telescopium telescopium* (Telescope Snail) from the family Ptamidiidae, *Umbonium vestiarium* (Common Bottom Top) from the Trochidae, *Perna viridis* (Asian Green Mussel) from the family Mytilidae, and an unidentified clam (*Ruditapes* sp.) from the family Veneridae.
- o Valued at USD \$102,314 ecosystem services

Table 4.F.1 List of species in TMTP.

Family	Scientific Name	English Name	Local Name	Density (indvl/ha)
Fish				
Ambassidae	<i>Ambassis gymnocephalus</i>	Bald Glassy	Langaray	96.9
	<i>Ambassis sp 1</i>	Glassfish	Langaray	3.3
	<i>Ambassis sp 2</i>	Glassfish	Langaray	4.9
	<i>Ambassis marianus</i>	Estuary Glassfish	Langaray	13.1
Anguillidae	<i>Anguilla marmorata</i>	Giant Mottled Eel	Palos	1.6
Carangidae	<i>Carangoides armatus</i>	Long Fin Trevally	Talakitok	3.3
	<i>Caranx sp</i>	Jack / Trevally	Talakitok	1.6
	<i>Scomberoides sp.</i>	Queenfish	Lapis	3.3
Chanidae	<i>Chanos chanos</i>	Milk fish	Bangus	54.2
Cichlidae	<i>Sarotherodon melanotheron</i>	Blackchin Tilapia	Tilapia Arroyo	517.4
Cynoglossidae	<i>Paraplagusia sp.</i>	Tonguefish	Dapa	19.7
Cyprinidae	<i>Tor tambroides</i>	Thai Mahseer	Upos	23.0
	<i>Saurida tumbil</i>	Greater Lizardfish	Kalaso	27.9
Dorosomatidae	<i>Anodontostoma sp.</i>	Gizzard Shad	Talandi	75.6
	<i>Sardinella fimbriata</i>	Fringescale Sardinella	Tunsoy	36.1
	<i>Sardinella sp.</i>	Sardinella	Tamban	3.3
	<i>Nematalosa nasus</i>	Bloch's Gizzard Shad	Kabasi	34.5
Echeneidae	<i>Remora remora</i>	Shark Sucker	Kumi	1.6
Elopidae	<i>Elops hawaiiensis</i>	Hawaiian Ladyfish	Bidbid	8.2

Gerridae	<i>Gerres filamentosus</i>	Whipfin Silver-Biddy	Malakapas	4.9
	<i>Gerres</i>	Mojarra	Malakapas	6.6
	<i>Amblygobius sp. 1</i>	Goby	Biya	8.2
	<i>Ambyglobius sp 2</i>	Goby	Biya	3.3
Gobiidae	<i>Ambyglobius sp 3</i>	Goby	Biya	4.9
	<i>Glossogobius aureus</i>	Golden Tank Goby	Biya Tabang	29.6
	<i>Oxyurichthys microlepis</i>	Maned Goby	Talimusak	3.3
Haemulidae	<i>Pomadasys kaakan</i>	Javelin Grunt	Aguot/Bakoko	14.8
Hemiramphidae	<i>Hyporhamphus sp.</i>	Halfbeak	Boging	3.3
Latidae	<i>Lates sp</i>	Lates Perches	Ayungin	1.6
	<i>Leignathus sp.</i>	Ponyfish	Sapsap	9.9
Leiognathidae	<i>Leiognathus equula</i>	Common Ponyfish	Sapsap	8.2
	<i>Eubleekeria splendens</i>	Splendid Ponyfish	Taksay	1.6
Megalopidae	<i>Megalops cyprinoides</i>	Indo Pacific Tarpon	Buwan-Buwan	9.9
Mugilidae	<i>Crenimugil seheli</i>	Blue Spot Mullet	Kapak	124.8
	<i>Mugil cephalus</i>	Flathead Grey Mullet	Banak / Talilung	11.5
Nemipteridae	<i>Nemipterus japonicus</i>	Japanese Threadfin Bream	Bisugo	1.6
	<i>Platycephalus sp. 1</i>	Flathead	Biyang Dapa/ Biyang Sunog	41.1
Platycephalidae	<i>Platycephalus indicus</i>	Bartall Flathead	Sunog	13.1
	<i>Platycephalus sp. 2</i>	Flathead	Sunog	1.6
Pleuronectiformes	<i>Pleuronectiformes sp.</i>	Flounder	Dapa	13.1
Polynemidae	<i>Eleutheronema tetradactylum</i>	Fourfinger Threadfin	Bikaw	11.5
Scatophagidae	<i>Scatophagus argus</i>	Spotted Scat	Kitang	4.9
Sciaenidae	<i>Johnius belangerii</i>	Belanger's Croaker	Alakaak	3.3
Scombridae	<i>Rastrelliger brachysoma</i>	Short-bodied Mackerel / Short Mackerel	Hasa/Hasa-Hasa	4.9
	<i>Epinephelus sp.</i>	Grouper	Lapu-Lapu	1.6
Siganidae	<i>Siganus spp.</i>	Spinefoot / Rabbitfish	Danggit	1.6
Sillaginidae	<i>Sillago sihama</i>	Silver sillago	Asohos	3.3
Sphyrnaeidae	<i>Sphyrna sp.</i>	Barracuda	Barracuda	1.6
	<i>Terapon jarbua</i>	Crescent Grunter/ Crescent Perch	Baga-ong	6.6
Terapontidae	<i>Pelates quadrilineatus</i>	Four-lined Terapon	Babansi	1.6
Tetraodontidae	<i>Arothron sp.</i>	Puffer	Butete	27.9
Triacanthidae	<i>Trixiphichthys weberi</i>	Blacktip Tripodfish	Helicopter	21.4
Crustacean				
Portunidae	<i>Scylla serrata</i>	Mudcrab / mangrove crab	Alimango	34.5
	<i>Potunus pelagicus</i>	Blue crab / blue swimmer crab	Alimasag	634.0
	<i>Scylla sp.</i>	Mudcrab / mangrove crab	Alimango Bato	19.7
	<i>Podophthalmus vigil</i>	Stalk Eyed Swimmer Crab	Bultron	1.6
	<i>Charybdis feriata</i>	Crucifix crab	San Francsico	1.6
Polychaetas				

Potamididae	<i>Telescopium telescopium</i>	Telescope Snail	Bagongon
Mytilidae	<i>Perna viridis</i>	Asian Green Mussel	Tahong
Trochidae	<i>Umbonium vestiarium</i>	Common Button Top	Common Button Top
Veneridae	Ruditapes sp	Clam	Halaan

Threats/Risks:

- Susceptible to over-exploitation
 - o Four capture methods used by communities – Gill Net (Tibog), Seine Net (Hatak/dala), Gill Net (Lambat), Nylon Net / Bamboo or Steel (Bubo)
 - o Garbage deposition and pollution from nearby Manila dumpsite
 - o Charcoal – making of mangrove trees
 - o Fauna hunted for food by informal settlers

Fish and Fisheries Situation in Fisheries Management Area (FMA) 5 and 6: Philippine Fishing Grounds in the Philippine Waters of the South China Sea-Large Marine Ecosystem (SCS-LME)

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Abstract

The Philippine fisheries sector plays an important role in the national economy, contributing to food security, nutrition, employment, and livelihoods. The SCS-LME is critical for marine biodiversity and fisheries. Effective management of these resources is essential for the sustainability of the fisheries sector and food security. Fisheries management areas (FMAs) covering all Philippine waters was established based on stock ranges, administrative subdivisions, and distribution of fisheries, with FMA 5 and 6 situated in the SCS waters. This report examines the status of fisheries and ecosystem health in the SCS and identify key fisheries issues and threats i.e.: (i) overfishing and depletion of fish stock in coastal waters; (ii) illegal unreported and unregulated (IUU) fishing; (iii) environmental degradation (pollution and coastal habitat destruction); and (iv) climate related impacts on fisheries. The report also provides opportunities for regional capacity building needs for improving fisheries management in SCS including regional data and information sharing. Regular conduct of resource surveys and stock assessments, scientific studies on impacts of climate change on major fish stocks, and establishment and monitoring of fisheries refugia are recommended for national priority actions.

Keywords: Fisheries status, fisheries management area, South China Sea

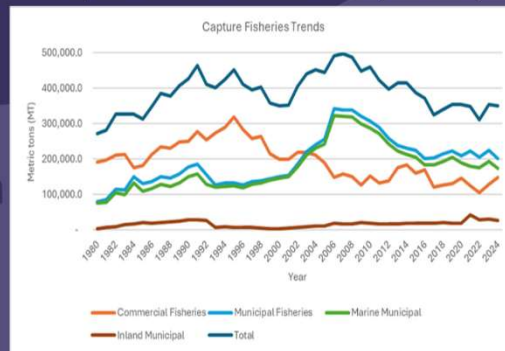
Fish and Fisheries Situation in FMA 5 and 6:

Philippine Fishing Grounds in the South China Sea-Large Marine Ecosystem (SCS-LME)

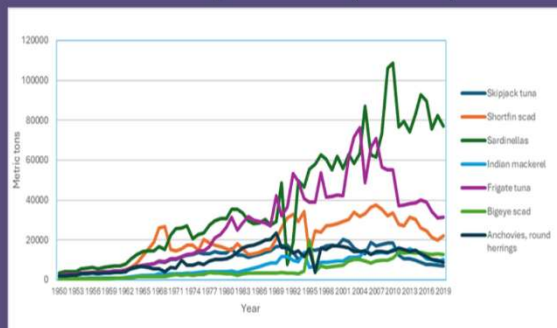


20%
Estimated contribution of capture fisheries in SCS waters to Philippine domestic

Capture Fisheries Production Trends (1980-2024)



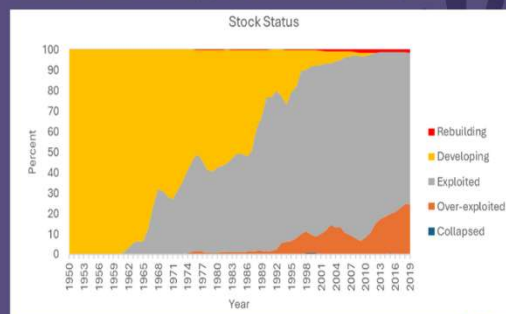
Catch Composition Trends (1950-2019)



Dominant
fish species from capture fisheries in SCS are small pelagics and tuna

Stock Status of Philippines Fisheries Catch (1950-2019)

Majority
of fish stocks may be experiencing excessive or heavy fishing pressure



5. Fish and Fisheries

The Philippine fisheries sector plays an important role in the national economy, contributing to food security, nutrition, employment, and livelihoods. The fisheries sector of the Philippines is categorized into commercial fisheries, municipal fisheries, and aquaculture. Commercial fisheries refer to capture fishing operations using fishery vessels of over 3 gross tons (GT) outside the municipal waters (beyond 15 km from the shoreline), and are classified into: a) small scale using passive or active gear and utilizing fishing vessels of 3.1–20 GT; b) medium scale utilizing active gears and vessels of 20.1–150 GT; and c) large scale utilizing active gears and vessels of more than 150 GT. On the other hand, municipal fisheries refer to capture fishing operations along coastal and inland waters with the use of fishing vessels of 3 GT or less including other forms of fishing not involving the use of watercraft. Aquaculture involves fish culture activities in inland and marine waters. The Bureau of Fisheries and Aquatic Resources (BFAR) under the Department of Agriculture is the government agency responsible for the development, improvement, management, and conservation of the fisheries and aquatic resources of the Philippines. Local Government Units (LGUs) have the mandate to manage municipal waters in coordination with the local Fisheries and Aquatic Resources Management Councils (FARMCs) in collaboration with BFAR.

In 2023, the Philippines produced about 4.26 million metric tons (MT) of fishery products and valued at PhP 328.74 billion (BFAR 2024). Aquaculture production including seaweeds contributed 2.38 million MT (or 56% of the total fisheries production), with an approximate value of PhP 124.02 billion. The combined production from the inland municipal and marine municipal fisheries sub-sectors amounted to a total municipal production volume of 1.05 million MT and valued at PhP 20.30 billion. For commercial fisheries, the total volume production amounted to 822,427.50 MT, valued at PhP 77.18 billion. Municipal fisheries contributed to 24.7% while commercial fisheries 19.3% of the total production. In addition, fishing and aquaculture activities recorded a value of PhP 274 billion or 12.0% share, following agricultural crops with 47.8%, and livestock with 13.3% (BFAR, 2024).

The Fisheries Code (Republic Act (RA) No. 8550 in 1998, as amended by RA No. 10654 in 2015) recognizes the ecosystem approach to fisheries (EAF) as the foundation for managing fisheries resources in natural fisheries management areas. In 2019, the Bureau of Fisheries and Aquatic Resources (BFAR) and the Fisheries Administrative Order (FAO) No. 263 formally established 12 fisheries management areas (FMAs) covering all Philippine waters based on stock ranges, administrative subdivisions, and distribution of fisheries (Figure 5.1). FMA 5 and 6 are situated in the South China Sea (SCS) large marine ecosystem (LME).

The delineation, establishment, and operationalization of FMAs involve two critical components. First, there is a deliberate effort to integrate the best available science into the process. And second, multi-sectoral collaboration and active engagement with stakeholders play a pivotal role. These features are essential for the success of FMAs in contributing to the national goal of achieving fish food security and fisheries sustainability (Ramiscal, et al., 2024).

The large marine ecosystems of the South China Sea and the Gulf of Thailand are critical for marine biodiversity and fisheries. Effective management of these resources is essential for the sustainability of the fisheries sector, which supports millions of livelihoods. However, without updating and reanalyzing the region's transboundary diagnostic problems, it isn't easy to take further actions to ensure the health of these ecosystems. National Transboundary Diagnostic Analysis (TDA) is only a fundamental process for assessing and managing aquatic ecosystems within and between neighboring states.

In the preparation of the national TDA report for the Philippines, the regions and provinces in the waters of national jurisdiction within the large marine ecosystems of the South China Sea are listed in Table 5.1. Fisheries production data for the period 1950-2019 compiled by the Sea Around Us project (<https://www.seaaroundus.org/>) for Philippine waters in the SCS LME was used and complemented with the fisheries statistics data obtained from the

Philippine Statistics Authority. The goal of this TDA report is to identify and develop a strategic action plan or program at the national level as well support the regional transboundary management initiatives in the SCS LME.

Table 5.1. FMAs, regions and provinces covered by the national TDA for the Philippines with in in the SCS LME.

FMA	Area	Regions/Provinces	Regions/Provinces covered by national TDA report
FMA 6	293,930 km ²	Region 1: Ilocos Norte, Ilocos Sur, La Union, Pangasinan Region 3: Bataan, Bulacan, Pampanga, Zambales Region 4A: Batangas, Cavite Region 4B: Occidental Mindoro CAR: Abra	Region 1: Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Region 3: Bataan, Bulacan, Pampanga, Zambales Region 4A: Batangas, Cavite Region 4B: Occidental Mindoro
FMA 5	485,415 km ²	Region 4B: Aklan, Antique, Occidental Mindoro, Palawan ARMM: Tawi-tawi	Region 4B: Occidental Mindoro, Palawan

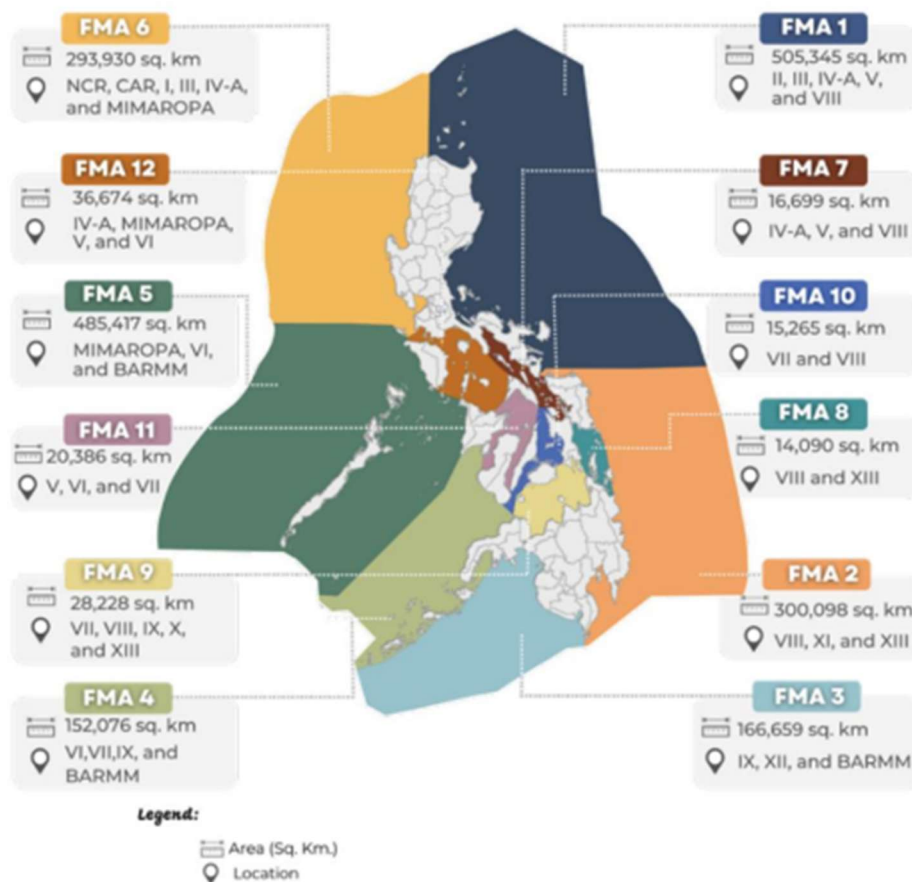


Figure 5.1. Area and Location of the Fisheries Management Areas in the Philippines (BFAR, 2024).

5.1 Key Findings

The Philippine waters of the SCS LME support rich marine biodiversity and productive fisheries resources. In 2024, total capture fisheries production from domestic catches in the SCS LME was estimated at 350 thousand MT. Of this, 201 thousand MT from municipal fisheries sub-sector and 149 thousand MT from commercial fisheries. Catch trends continue to show decreasing trends since 2008, specially from marine municipal fisheries.

The *Comprehensive National Fisheries Industry Development Plan (CNFIDP), 2016-2020* reports that the Philippine fisheries sector is confronted with nine key and interlinked problems/issues, namely (BFAR, 2016): (i) depleted fishery resources largely brought about by excessive fishing effort and the open access regime in Philippine fisheries; (ii) degraded fishery habitats due to destructive fishing methods, conversion of fishery habitats into economic uses, and negative impacts from land-based activities; (iii) intensified resource use competition and conflicts among fisher groups and other economic sectors; (iv) unrealized full potential of aquaculture and commercial fisheries in view of the still underutilized areas for industry development; (v) uncompetitive products due to inferior quality and safety standards; (vi) postharvest losses in terms of physical, nutritional and value losses; (vii) limited institutional capabilities, from the local up to the national level of governance; (viii) inadequate/inconsistent fisheries policies for promoting a conducive environment for sustainable development; and (ix) weak institutional partnerships among government agencies both at the national and local levels, civil society organizations (CSOs), and the private sector.

Based on the FMA Framework Plans, the following issues and threats to be addressed in FMA 5: (i) Overfishing; (ii) Habitat degradation; (iii) weak compliance with existing fishery laws rules and regulations/ IUU Fishing; (iv) weak governance; (v) low capacity for fisheries management; and (vi) decreasing income due to low fish catch, and lack of livelihood support and diversification (BFAR – FMA 5, 2023). On the other hand, the focus of the framework plan for FMA 6 include: (i) declining fish catch; (ii) IUU Fishing (in municipal waters and beyond); (iii) resource use conflicts; (iv) inadequate income; and (v) poor market linkages (BFAR – FMA 6, 2023).

This TDA Fisheries component report identified the following key fisheries issues and threats within Philippines waters in SCS LME:

- **Overfishing and depletion of fish stock in coastal waters** – this situation is mainly attributed to unsustainable fishing practices leading to declining fish catch trends and mean trophic level or catches, as well as biodiversity loss.
- **IUU fishing** – based on reports there are encroachments of commercial fishing boats in municipal waters as well as presence of foreign flagged fishing vessels in fishing grounds and areas within Philippine territory. The lack of compliance to fisheries regulations such as operation of unlicensed commercial fishing vessels and use of destructive fishing gears also contribute to unsustainable fisheries situation.
- **Environmental degradation** (pollution and coastal habitat destruction) - resource use conflicts including coastal developments in coastal areas have resulted in environmental degradation from water pollution and habitat destruction (coral reefs, seagrass beds, mangroves). The destruction of critical fisheries habitats contributes to the challenges to maintaining productive fisheries habitats and healthy fish stocks.
- **Climate related impacts on fisheries** – there are limited studies on climate change impacts on fisheries. Reductions or shifts in suitable habitats and changes in primary productivity can affect the fish stocks. Occurrence of frequent typhoons can result to reductions of effective fishing days and loss of income.

The report also outlines regional capacity building needs for improving fisheries management in SCS including regional data and information sharing, as well as regular conduct of resource surveys and stock assessments. Scientific studies on impacts of climate change on major fish stocks must be carried out due to limited data and information on this topic. The establishment and monitoring of fisheries refugia, building on previous SCS projects in the region is also proposed.

5.2. Current Status of Fisheries and Ecosystem Health

5.2.1 Based on Fisheries Indicators

Capture Fisheries Status and Trends

The Philippine waters of the SCS LME support rich marine biodiversity – from species to ecosystems, and the fisheries production they provide (Arceo et al., 2024). Based on the Philippine Statistics Authority (PSA) data, in 1980 the capture fisheries production from Philippine waters in the SCS LME was about 271 thousand MT and increased to about 498 thousand MT in 2007. From 2008 the capture fisheries production showed a declining trend until 2024 (i.e., from 487.5 thousand MT in 2008 to 353.8 thousand MT).

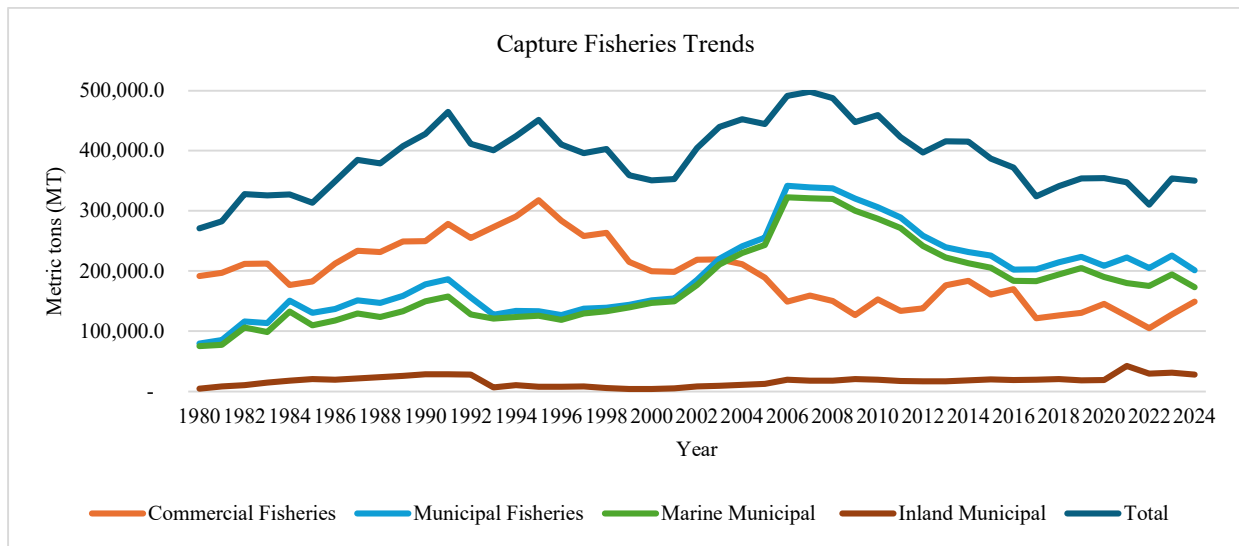


Figure 5.2. Capture fisheries production trends (1980 – 2024) from commercial and municipal subsector in Philippine waters in the SCS LME (PSA data)

Based on the compiled and reconstructed fisheries data from the Sea Around Us project, the trend shows an increasing trend in capture fisheries production from 1960s to 2009, then in 2010 catch from industrial i.e., defined as ‘commercial’ and include boats of 3 GT deploying dragged gears such as trawls either within or outside of municipal waters (Palomares and Pauly 2014) recorded 427 thousand MT and showed a declining trend until 2019. On the other hand, artisanal fisheries also showed decreasing trend from 2010 (188 thousand MT) to 2019 (135 thousand MT). Also referred to as ‘municipal’. The Sea Around Us definition of artisanal fishing in the Philippines is of the fleet of boats weighing 3 GT and less, and does not account for the fact that boats of 3 GT can deploy gears (such as bottom trawls) similar to those deployed by industrial vessels (Palomares and Pauly, 2014).

The catches reported from the SCS by the bordering countries were observed that artisanal fisheries contributed to 25% while 75% from industrial (commercial) sector, and the estimated contribution of Philippines domestic catch to SCS is about 27% of the total capture fisheries production (Pauly and Liang, 2020). In addition, the reported 10 million MT total catch level was achieved by “fishing down the food web” or catching smaller fish in the lower trophic level of the food web as bigger (and thus, more valuable) fish in the higher trophic level of the food web are depleted due to over-exploitation.

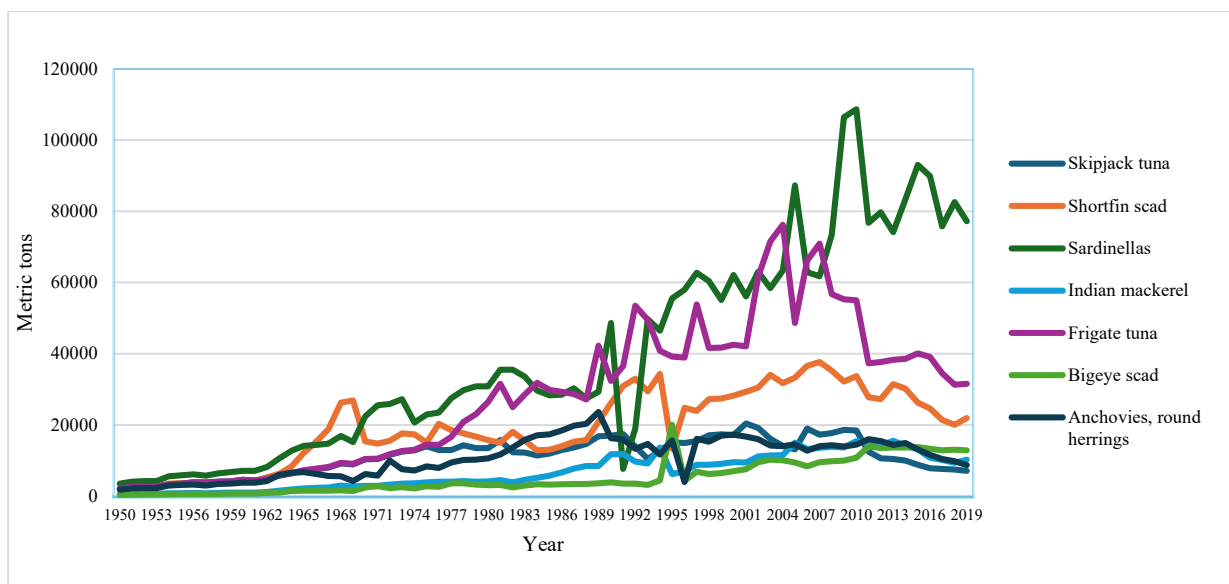


Figure 5.3. Catch composition trends (1950 – 2019) (Sea Around Us project data <https://www.seaaroundus.org/>)

Status of stocks

Major Philippine fisheries have been considered overfished since 1990s (Barut et al., 2003, Green et al., 2003), and fish catch has been declining (Mualill et al., 2014). A report on status of small pelagic fish resources in the Lingayen Gulf (2009-2013) showed that almost 50% of the total fish harvest in are small pelagics and the commercial fisheries sector contributed the largest catch (Gaerlan et al., 2018). The commercial fishing gears that mostly catch small pelagic fish are the Danish seine and Trawl with a catch per unit of effort ranging from 899 to 1,186 kg/day and 65.98 to 119.77 kg/day, respectively. The dominant small pelagic species are *Decapterus maruadsi*, *Decapterus macrosoma*, *Selar crumenophthalmus*, *Rastrelliger brachysoma*, and *Rastrelliger kanagurta*. The estimated mortality parameters and exploitation values obtained from stock assessments for dominant small pelagic fish species are presented in Table 5.2. Results of stock assessment (1998 – 2002 for *D. macrosoma*, *Selaroides leptolepis* and *R. kanagurta*) from northern Zambales waters are also included in Table 5.2. The assessments have indicated some levels of overfishing among the dominant small pelagic species. The exploitation values are way above the “optimum” values of 0.3 - 0.5 suggested by conventional fisheries theory and imply very heavy fishing pressure from the mix of gear used.

The Atlas of Capture Fisheries published by the National Fisheries Research and Development Institute (NFRDI) (Santos et al., 2017) showed that the majority of fish stocks are experiencing excessive or heavy fishing pressure. The National Stock Assessment Program (NSAP) also generated reference points for 42 fish species (47 stocks) and proposed HCRs that can inform policymaking even by relevant management bodies such as those in FMAs 5 and 6. 6 and 9. Table 5.2 provides a list of fish species in FMA 5 and 6 that were reported to be exploited. The exploitation values are way above the “optimum” values of 0.3 - 0.5 suggested by conventional fisheries theory and imply very heavy fishing pressure from the mix of gear used.

Table 5.2. Estimates of mortality parameters and exploitation values for dominant small pelagic fish species from Lingayen Gulf (Gaerlan et al., 2018) and Northern Zambales waters (Rueca, et al. 2009).

Species	Total Mortality (Z)	Natural Mortality (M)	Fishing Mortality (F)	Exploitation value (E =)	Source
<i>Decapterus maruadsi</i>	4.18	1.97	2.21	0.51	Gaerlan et al. 2018
<i>Decapterus macrosoma</i>	3.97	2.06	2.53	0.57	Gaerlan et al. 2018
	12.90	2.90	10.0	0.78	Rueca. et al. 2009

<i>Selar crumenophthalmus</i>	8.40	1.91	6.49	0.75	Gaerlan et al. 2018
<i>Selaroides leptolepis</i>	19.36	5.87	13.49	0.70	Rueca. et al. 2009
<i>Rastrelliger brachysoma</i>	6.17	1.91	4.26	0.68	Gaerlan et al. 2018
<i>Rastrelliger kanagurta</i>	3.76	1.98	1.77	0.50	Gaerlan et al. 2018
	4.15	1.84	2.31	0.56	Rueca. et al. 2009

Fish stock assessment data collation for roundskad *Decapaterus macrosoma* (Gonzales et al., in press.) and lizardfish *Saurida tumbil* (NSAP Region 1 and 3, in press) indicated relatively high fishing pressure for these species in FMA 5 and FMA 6, respectively. Annex 5.A.1 also provides the growth, mortality parameters and exploitation values of different species caught in FMA 5 and 6 fishing grounds of the Philippines that was obtained from Silvestre et al. (2003). Based on 2019 data of the Sea Around Us project, the status of fish stocks that were categorized “exploited” with about 73.6% of fisheries catch, while 24.5% were considered “over-exploited” (Figure 5.4). The Atlas of Capture Fisheries published by the National Fisheries Research and Development Institute (NFRDI) (Santos et al., 2017) also indicated that the majority of fish stocks maybe experiencing excessive or heavy fishing pressure.

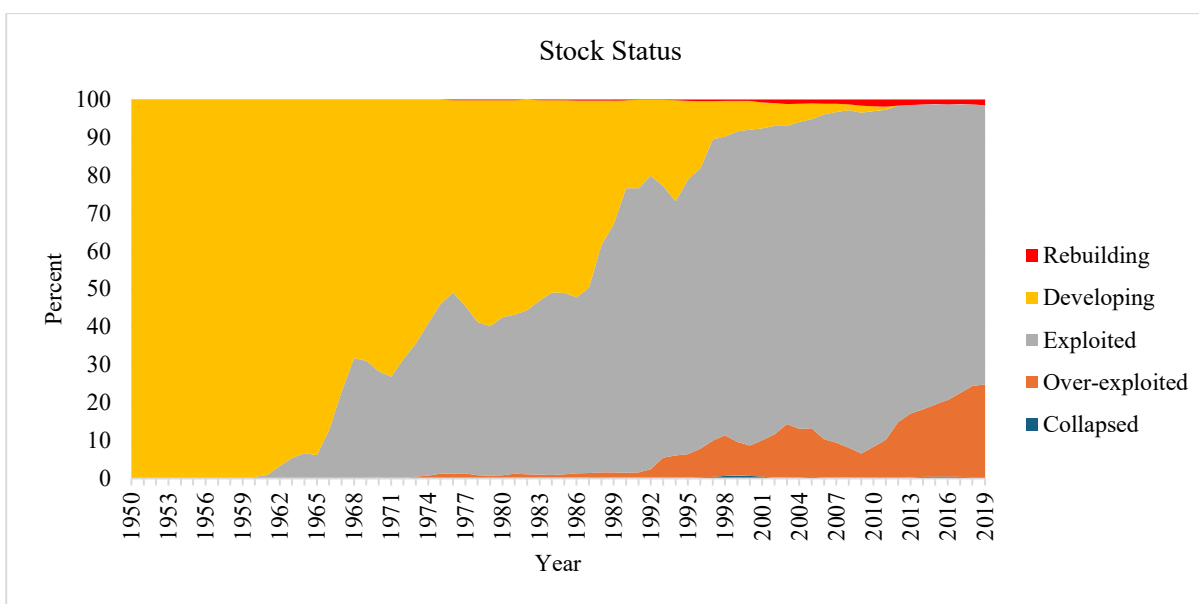


Figure 5.4. Stock status of Philippines fisheries catch (1950 – 2019). (Sea Around Us project data <https://www.seararoundus.org/>)

In 1998 – 2000 (during March to May) an exploration of purpleback flying squid (*Sthenoteuthis oualaniensis*) resources in the SCS and its fishing ground were conducted by using MV SEAFDEC of the Southeast Asia Fisheries Development Center (SEAFDEC). The survey area in the South China Sea was divided into three areas, namely: Area I: Western Philippines waters; Area II: Vietnamese waters; and Area III: Sabah – Sarawak (Malaysia) and Brunei Darussalam waters. The survey results showed that in the Western Philippines waters, the catch per unit of effort (CPUE) of the oceanic squid averaged about 5.7 individual/line/hour, with the CPUEs of the squid ranging from 1.6 and 18.5 individual/line/hour (Siriraksophon, et al., 2001).

Figure 5.5 shows the CPUE distribution and sex composition of the squid caught at each sampling station, and it is apparent that females formed the majority of the catch, accounting for 1,383 squid or 81% of the 1,701 total catch. The resource survey estimated biomass of *S. oualaniensis* in the waters of western Philippines to be 283 thousand MT; the density averaged about 7.2 t/km², whereas the abundant area was as high as 26.4 t/km² during summer of 1998 (Labe 1999 cited by Siriraksophon, et al., 2001). The oceanic squid resources in western Philippine waters were considered under-utilized.

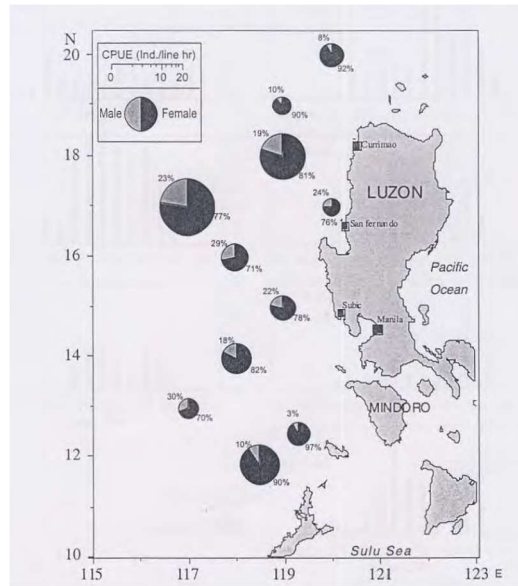


Figure 5.5. Sex composition and CPUE distribution of purpleback flying squid in the South China Sea, Western Philippines waters during April - May 1998 (Siriraksophon, et al., 2001)

Catch from Bottom-impacting gear

Table 5.3 shows the historical stock density and biomass in selected traditional trawl fishing areas in the Philippines noting that Manila Bay and San Miguel Bay are situated in the western seaboard facing the SCS LME. In addition, the E value confirms heavy fishing pressure of the fishery resources in the study areas and is consistent with the declines in demersal biomass. Annex 5.A provides a compilation of growth, mortality parameters and exploitation rates of different species caught in FMA 5 and 6 fishing grounds of the Philippines.

Table 5.3. Estimates of stock density and biomass in Manila Bay and Lingayen Gulf in the Philippines (Adopted from Garces and Silvestre 2003, Stobutzki et al., 2006).

Area	Year	Stock density (t km ²)	Relative density (%)	Stock biomass (t)	Source
Manila Bay	1949-52	4.61	100.0	8,240	Warfel and Manacop (1950)
	1992-93	0.47	10.2	840	UPV & MADECOR (1995)
	2014	0.32	6.9	618	Bendaño, et al. (2017)
	2015	0.48	10.4	928	Bendaño, et al. (2017)
Lingayen Gulf	1978-79	1.33			Villoso and Aprieto 1983
	1987-88	0.57			Ochavillo et al 1989

Silvestre and Hilomen (2004) suggested that trends in the species composition changes from trawl surveys in Lingayen Gulf from late 1940s to the late 1980s is reflective of overfishing which threatens the sustainability of fisheries in the gulf, for example: (1) relative increase in squids (cephalopods), triggerfish and “trash fish” components; (2) virtual disappearance of large species such as rays and lactarids (3) relative decrease of slipmouths, lutjanids (snappers) and flatfishes. In Manila Bay, comparison of the catch composition between the 1947's and the REA study (1990s) showed significant changes that are reflective of recruitment and ecosystem overfishing (MADECOR & National Museum 1995; Pura et al., 1996). The biomass of fished stocks declined in the mid-1980s to about 30% of levels in the late 1940s, resulting in an annual rent dissipation of about US\$130 million per year, due to over-fishing of demersal stocks (Silvestre et al., 1986).

Negative aspects from trawl fisheries also include overcapacity, excess fishing effort and, because trawls are poorly selective (usually by design), they can lead to the suboptimal harvest of juveniles of many species (FAO 2014). In addition, bottom trawling can adversely affect populations of commercially and biologically important target fish and impact species which are endangered, threatened or protected species (ETPs), do damage to benthic habitats and disrupt normal ecosystem functions.

In accordance with Section 95 of Republic Act (R.A.) No. 10654 otherwise known as the Act to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated (IUU) Fishing, amending Republic Act No. 8550, active gear such as bottom trawl is banned from operating within 15 kilometers from the coastline which, by law and as a matter of equity, is reserved for municipal fishers (Sec. 95 in relation to Sec. 4(44), Fisheries Code of the Philippines). Despite the prohibition, however, there is still a proliferation of bottom trawlers within municipal waters in various parts of the country, highlighting the need to strengthen the implementation of the ban of bottom trawl operations within municipal waters. Hence on 28 November 2018, a Joint Memorandum Circular (JMC) No.: 2018-03 was issued by Department of Interior and Local Government (DILG) and DA-BFAR re. Guidelines on Strengthening the Implementation of the “Ban on Bottom Trawl Operations within Municipal Waters”. The purpose of this policy issuance is to clarify roles and responsibilities of the LGUs, DILG and BFAR to conserve, and protect municipal waters from the adverse ecological, and socioeconomic impacts of bottom trawl operations for the benefit of municipal fisherfolk.

Catch trends of major fishing gears

The major fishing gears used by commercial sector include purse seine for catching pelagic fishes while bottom trawl for demersal species. Figure 5.6a and 5.6b shows the catch trends of major commercial and municipal fishing gears in the SCS waters within the Philippines. It should be noted that bottom trawl and purse seine showed catch in declining trends in 2010, while small scale lines indicated steep catch declined from 2009-2011. The percentage contribution trends of small-scale and commercial fishing gears in the SCS (1950 – 2022) is also shown in Figure 5.6c indicating that purse seines contribute to about 40% of the fisheries catches in the SCS mostly comprised of small pelagic species (see Figure 5.3).

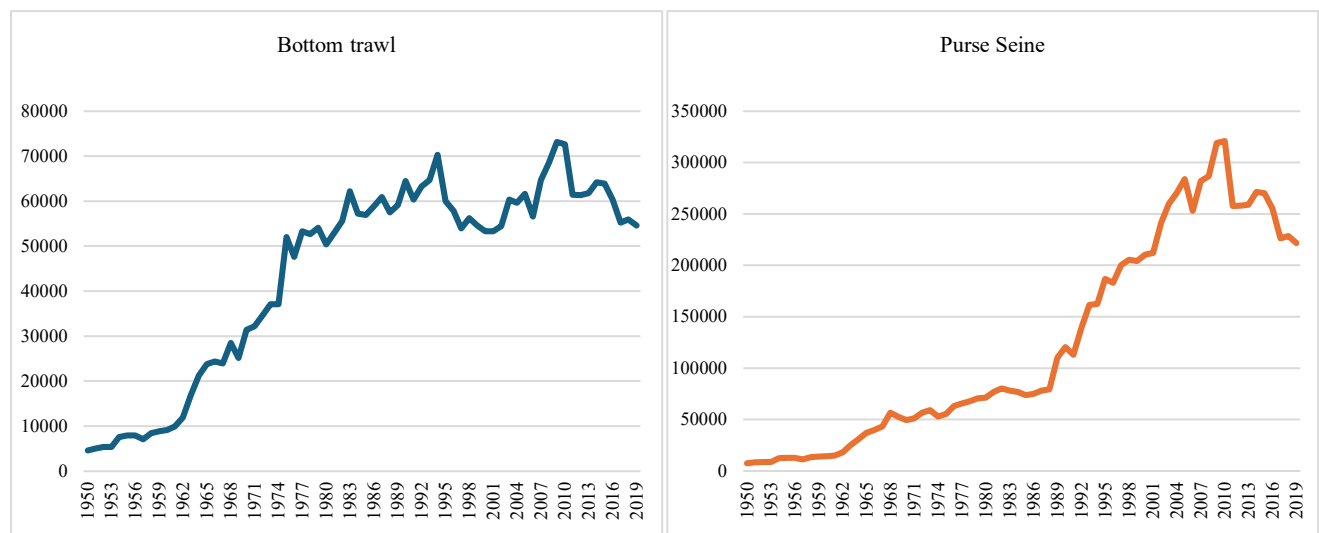


Figure 5.6a. Catch trends of commercial fishing gears in the SCS (1950 – 2019). (Sea Around Us project data <https://www.searoundus.org/>)

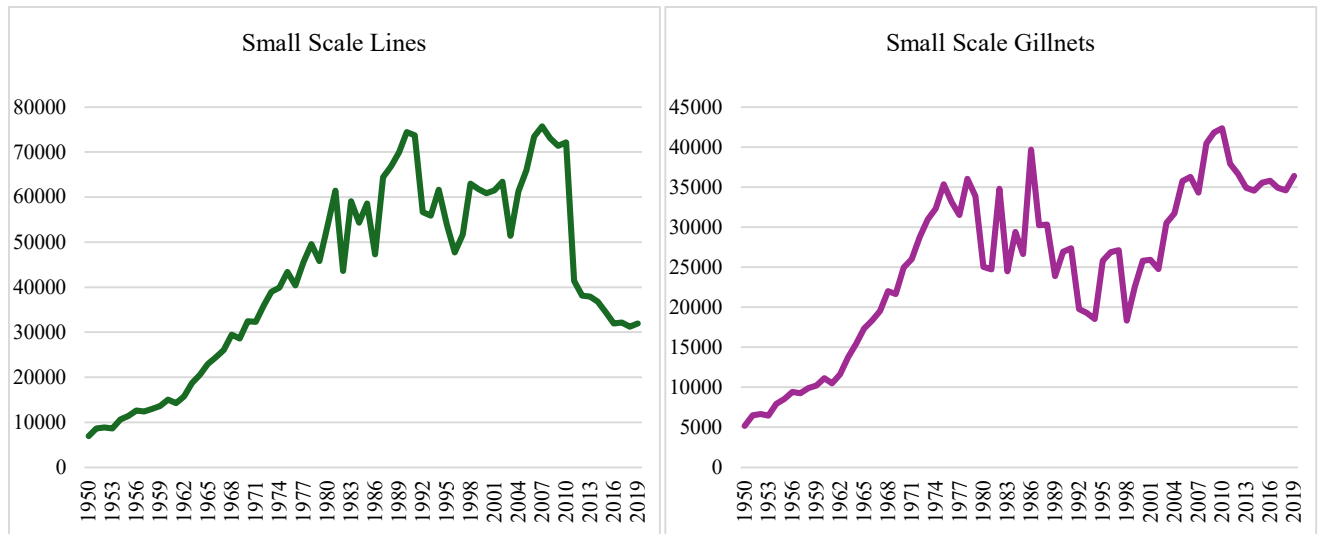


Figure 5.6b. Catch trends of municipal fishing gears in the SCS (1950 – 2019). (Sea Around Us project data <https://www.seaaroundus.org/>)

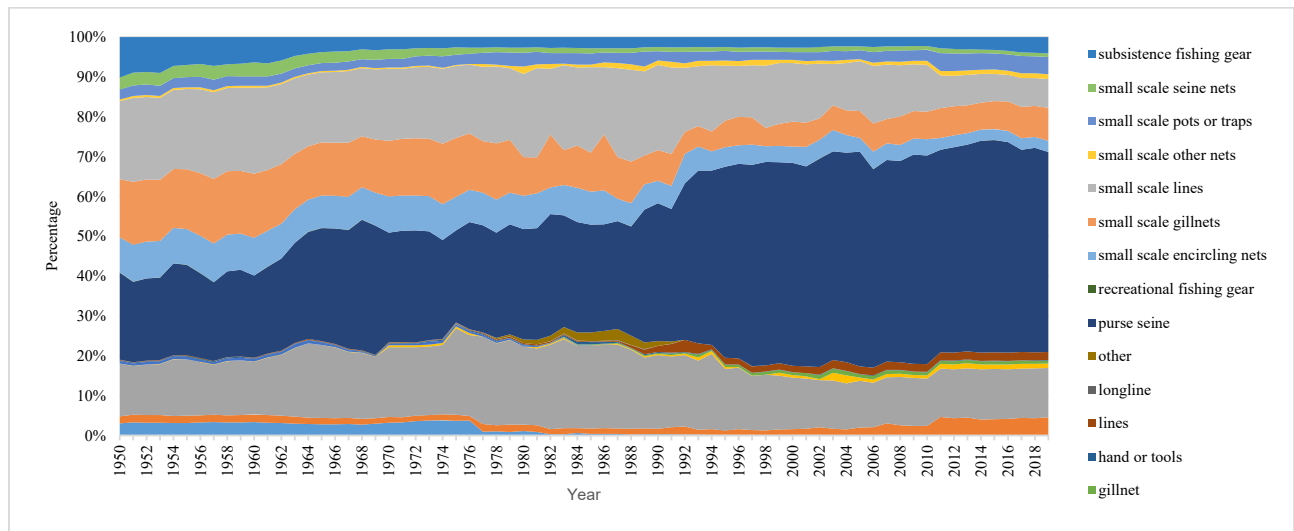


Figure 5.6c. Percentage contribution trends of small-scale and commercial fishing gears in the SCS (1950-2019) (Sea Around Us project data <https://www.seaaroundus.org/>)

Fishing effort

In 2023, BFAR reported that approximately 2.30 million registered fisherfolk engaging in various types of fishery-related livelihoods across the different municipalities in the country (FishR, 2023 cited in BFAR, 2024). Capture fishing constitutes approximately 50.9% of the overall livelihood distribution, indicating that it is the prevailing source of income among fisherfolk, followed by aquaculture at 11.4%, gleaning at 11.1%, fish vending at 7.0%, fish processing at 2.0%, and others composing 17.6%. Table 5.4 provides the number of registered fisherfolks and Table 5.5 shows the number of fishing vessels/boat by regions that are with the SCS LME, and Table 5.6 provides the number of boats by region and GT category based on PSA 2023 data.

Table 5.4. Number of fisherfolks that are engaged in capture fisheries by region (BFAR, 2024)

Region	Male	Female	Total
NCR	8,663	544	9,207
Region 1	53,346	4,016	57,362

Region 2	52,940	4,436	57,376
Region 3	69,700	4,553	74,253
Region 4A	91,144	7,786	98,930
Region 4B	92,985	12,984	105,969
SCS	368,778	29,766	403,097
PH Total	1,061,180	109,682	1,170,862

Table 5.5. Number of registered fishing vessels/boats by region facing the SCS LME (BFAR Fisheries Profile 2024; 2020; 2010; 2000).

Region	2023		2010		2000		1990	
	Municipal	Commercial	Municipal	Commercial	Municipal	Commercial	Municipal	Commercial
NCR	2,744	646	-	758	-	1,351	3,553	323
1	17,964	112	17,678	74	17,678	113	12,720	3
2	12,700	64	3,304	111	3,304	64	3,085	-
3	17,815	212	27,038	137	27,038	40	21,433	27
4A	32,567	160	69,927	226	69,927	221	54,657	1,102
4B	41,280	443	-	455	-	-	-	-
SCS	112,370	1,637	114,643	1,195	114,643	1,725	92,363	1,455
PH Total	407,215	4,560	469,807	6,365	469,807	3,603	464,415	3,278
				*2000		**1999	1985 data	1989 data

Table 5.6. Number of registered fishing vessels/boats by region and by GT category in 2023 (BFAR Fisheries Profile 2024).

Region	Municipal (3 GT or less)	Commercial	3.1-20 GT	20.1-150 GT	>150 GT
NCR	2,744	646	142	367	137
1	17,964	112	100	12	0
2	12,700	64	62	2	0
3	17,815	212	126	86	0
4A	32,567	160	122	38	0
4B	41,280	443	339	100	4
SCS	112,370	1,637	891	605	141
PH Total	407,215	4,560	1,981	2,224	355

5.2.2 Based on Ecosystem Health Indicators

Marine Trophic Index (MTI) and Fishing-in-Balance Index (FiB)

The marine trophic index (MTI) measures the change in mean trophic level of fisheries catches from an ecosystem, adequately tracks changes in mean trophic level of an ensemble of exploited species in response to fishing pressure. The Fishing-in-Balance (FiB) index aim to account for the expansion and contraction of fishing fleets over time as reflected by the trophic level of the catches. Harvesting lower trophic level species has been happening in the Philippines has been observed and indicates the declining trend in the mean trophic level of the Philippines fishery catches, as reported by (Cabral et al., 2023).

An analysis of the mean trophic level of the reconstructed industrial (commercial fisheries) catch for which landings data were disaggregated to the species-level also implied the presence of the ‘fishing down the food web’ phenomenon (Palomares and Pauly 2014), i.e., catching smaller fish lower in the food web, and through a demand-

and subsidy-driven offshore expansion (Pauly and Liang, 2020). Figure 5.7 shows the MTI and FiB indices based on capture fisheries data from SAUP in the waters of Philippines (1950 – 2019).

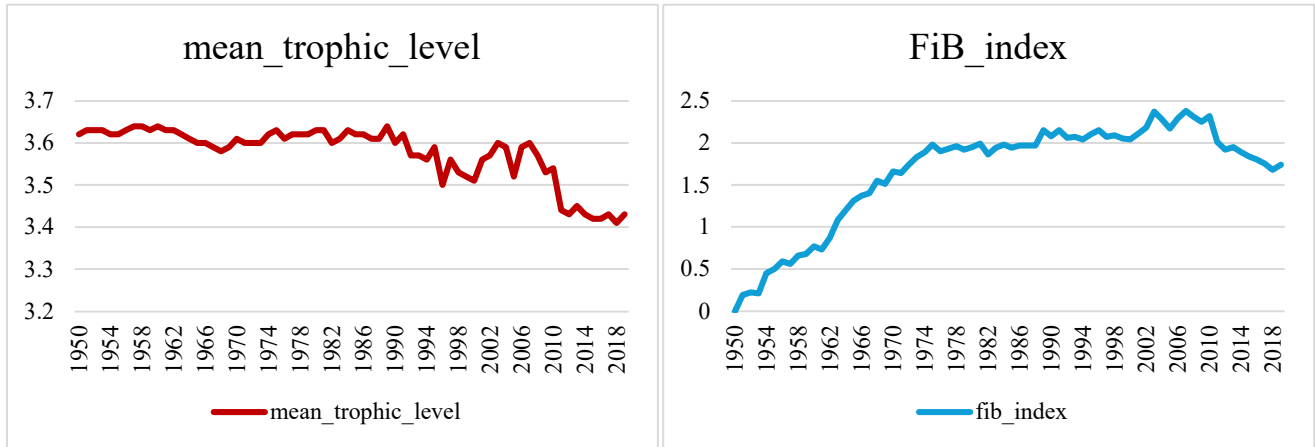


Figure 5.7. Marine Trophic Index (MTI) and Fishing-in-Balance Index (FiB) for catches in the waters of Philippines (1950 – 2019) (Sea Around Us project data <https://www.seaaroundus.org/>).

Primary Production Required (PPR)

The Primary Production Required (PPR) index is a crucial tool for evaluating the ecological footprint of fisheries. It provides a comprehensive understanding of the impacts of fishing activities on marine ecosystems and facilitates sustainable fishery management. By using rigorous assessment methodologies, stakeholders can ensure the preservation of marine biodiversity and the long-term viability of fishery resources. As the demand for marine resources increases, the importance of PPR as an ecological metric will remain vital in guiding responsible and sustainable fishing practices. Figure 5.8 presents the PPR for fisheries catches in the waters of Philippines.

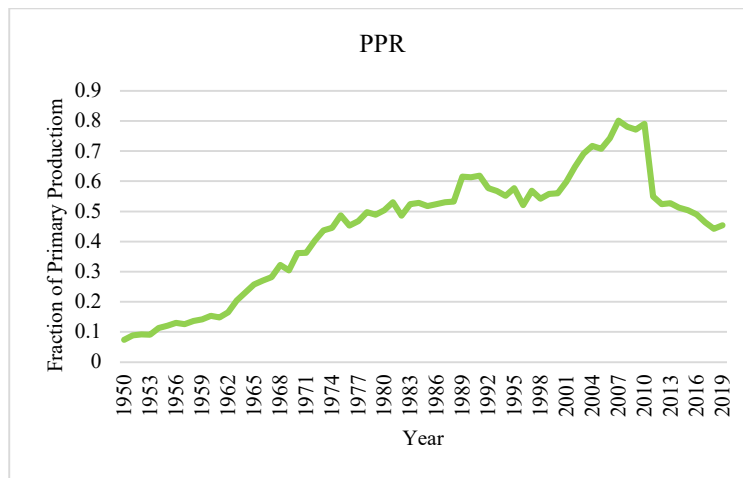


Figure 5.8. Primary Production Required for catches in the waters of Philippines (1950 – 2019) (Sea Around Us project data <https://www.seaaroundus.org/>).

In addition, a study was conducted to estimate primary productivity in the South China Sea off the coast of Western Philippines indicated that the net primary production estimated from ten sampling stations ranged from 0.10 to 1.53 g C m⁻² d⁻¹ during April 15 to May 11, 1998 (Furio and Borja, 2000). The result of the study showed relatively low primary production in that area and suggests some parts of the ecosystem may be vulnerable. It must be noted that an area with low primary production has less energy entering the food web, and it can naturally support a lower

total biomass of fish than a highly productive area (i.e., coastal upwelling zones). Moreover, in a low-productivity ecosystem, even a modest fishery can represent a large fraction of the total available energy (a high PRR%). And catching the same tonnage of fish in the Philippines might have a much larger ecological footprint (higher PRR) than catching it in a highly productive area. Based on a remote sensing study in the Luzon strait in the SCS, the area was identified as typical oligotrophic region where primary productivity is limited by nutrient availability (Tang et al., 1999).

5.3 Discussion and Conclusions

5.3.1 Transboundary Problems and Issues and Risk Assessment

The following issues were identified in the Philippines national TDA report that contribute to the problem on overexploitation of marine living resources in the SCS LME (UNEP undated): (i) reduced fish stock and declining fish biomass; (ii) reduced biodiversity; (iii) degradation of coastal habitats; (iv) reduced coastal productivity; (v) increased resource use conflicts and competition between commercial and municipal fishing sectors; and (vi) declining catch rates and income of fishers, among others. Regionally significant threats to coral reefs in the SCS were overfishing, use of destructive fishing techniques, pollution (mainly eutrophication) and increased sedimentation (Vo et al., 2013).

In south and southeast Asia including the Philippines, the key issues impacting coastal fisheries include (Silvestre and Pauly 1997): (i) overfishing, (ii) inappropriate exploitation patterns, (iii) post-harvest losses, (iv) conflict between large- and small-scale fisheries, (v) habitat degradation, (vi) inadequacy of management information and research, and (vii) institutional weakness and constraints.

Illegal fishing is also prevalent, and commercial fishing intrusion into municipal waters has been identified as a top threat (Green et al. 2003, DA-BFAR 2024). Poaching by foreign entities is also considered the most challenging threat to Philippine fisheries, especially in SCS LME and access to several reef areas have become restricted due to the presence and encroachment of foreign flagged (Arceo et al., 2024).

As part of the national continuing commitment to address IUU fishing and its strategic vision of reducing destructive practice, DA-BFAR has been seeking solutions to the still significant knowledge gaps that remain in the current understanding of IUU fishing in the Philippines. Based on the DA-BFAR IUU report (DA-BFAR 2024), the top three violations of commercial fishing vessels (CFV) based on the number of incidents in 2022 for both FMAs 5 and 6 were (DA-BFAR 2024): (1) unauthorized fishing (fishing without registration); (2) CFV intrusion in municipal waters; and (3) CFV operators employing unlicensed fishworkers (Table 5.7). Other violations reported were: use of unlicensed gear; fishing using explosives; and use of prohibited gear (ban on muro-ami).

Table 5.7. Violations by CFVs involved in IUU fishing in FMA 5 and FMA 6 (DA-BFAR, 2024)

Commercial Vessel IUU Violation	FMA 5	FMA 6
Unauthorized fishing	50%	29%
CFV intrusion in municipal waters	38%	22%
CFV operators employing unlicensed fish workers	6%	15%

Based on data from apprehension reports and IUU fishing reports from BFAR, CFVs engaged in IUU fishing in FMA 5 were estimated to catch about 558 MT of fish per year valued at nearly Php56 million while in FMA 6 the estimate was 756 MT, and valued about Php75 million (DA-BFAR 2024). In addition, Philippines coastal waters within the SCS LME accounted for the highest number of suspected IUU fishing activities by foreign-flagged vessels in 2020 (OceanMind, 2022 cited in DA-BFAR, 2024). IUU fishing constitutes a persistent and pressing problem,

estimated to account for up to \$23 billion annually in the Asia Pacific region (Wilcox et al., 2021). Hotspot areas of illegal fishing activities are included in the regions encompassing the border of Vietnam's EEZ and the SCS, and the region between the Philippines and Indonesia in the Celebes Sea.

With regards to the intrusion of commercial fishing vessels in municipal waters. On August 19, 2024, the Supreme Court (SC) First Division upheld a Malabon Regional Trial Court (RTC)'s ruling that allows the Mercidar Fishing Corporation, a commercial fishing operator, to operate in municipal waters. The RTC's ruling allows Mercidar to operate in all territorial waters of the Philippines, including within the 15-kilometer municipal water zone, so long as such bodies of water are seven fathoms or more deep and so long as it is duly licensed to operate as a large commercial fishing operator pursuant to Section 26 of RA 8550, as amended. In January 2025, the Department of Agriculture (DA), through the Office of the Solicitor General, filed a motion for reconsideration with the Supreme Court to overturn a decision allowing commercial fishing vessels access to municipal waters, previously reserved for small-scale fishers under the Fisheries Code. Allowing commercial vessels to operate within municipal waters jeopardizes the livelihoods of thousands of subsistence fishers and accelerates the depletion of already fragile fish stocks. The potential impacts on small-scale fishers and municipal waters may include: (i) shrinking fishing grounds of municipal fisherfolk; (ii) further depletion of fish stocks in coastal areas; (iii) exploitation or destruction of marine protected areas (MPAs) and fish sanctuaries; and (v) intensify competition over the fisheries resources between municipal fishers and commercial fishers.

Considering the emphasis on addressing the three (3) interlinked planetary crises in the preparation of the national TDA (i.e., climate change, nutrient and plastic pollution, and biodiversity). For this fisheries report we considered the following transboundary problems/issues (see also **Risk Assessment**):

- Overfishing and depletion of fish stock in coastal waters (15-km municipal water and commercial fishing operations) (this issue was mentioned in the FMA 5 and 6 Framework Plans)
- IUU fishing (encroachment of commercial fishing boats in municipal waters and operation of foreign flagged fishing vessels within Philippines waters (this issue was mentioned in the FMA 5 and 6 Framework Plans)
- Habitat Destruction and Environmental Degradation (refer to **Chapter 4 – Ecosystems** (Wetlands, Mangroves, Seagrasses, and Coral Reefs) and **Chapter 3 - Pollution** chapters)
- Climate change impacts (see section 5.3.2 below)

It must be noted that overfishing and declining fish catch, IUU fishing in municipal waters and habitat destruction were identified as key issues and threats in the FMA Framework Plans for FMA 5 and FMA 6. These issues contribute to enhancing loss of biodiversity in productive fishing areas in the SCS.

5.3.2. Climate Change Impacts on Fisheries and Aquaculture

Barange et al. (2018) suggest that in marine region the climate model projections will result to decreases in maximum catch potential in the world's exclusive economic zones of between 2.8% and 5.3% by 2050 according to greenhouse gas emission scenario RCP2.6, and between 7.0% and 12.1% according to greenhouse gas emission scenario RCP8.5, also by 2050. The estimated projected changes in catch potential (%) in the Philippines by 2050 and 2100 relative to 2000 under RCP2.6 and RCP8.5 will be between -8.2% and -59.2% (Cheung et al., 2018).

Projections reveal that the Philippines shall experience increases in sea surface temperature more intense storms, locally prolonged droughts, and intense episodic rainfalls (David et al., 2016). The country is also likely to experience effects of ocean acidification, and sea level rise is projected to be higher than the global estimates for the Philippines. These impacts are additional pressure on top of the many, and mostly anthropogenic pressures which the marine ecosystem is already experiencing.

Fisheries and fisherfolk may be impacted in a wide range of ways due to climate change (Daw et al, 2009). These include biophysical impacts on the distribution or productivity of marine and freshwater fish stocks through processes such as ocean acidification, habitat damage, changes in oceanography, disruption to precipitation and freshwater availability. Fisheries will also be exposed to a diverse range of direct and indirect climate impacts, including displacement and migration of human populations; impacts on coastal communities and infrastructure due to sea level rise; and changes in the frequency, distribution or intensity of tropical storms. In aquaculture, climate change impacts include (i) damage to farming facilities and loss of stocks due to extreme weather events, (ii) changing salinity due to sea-level rise, (iii) production impacts from rising temperatures, water shortages during droughts, (v) loss of stocks due to flooding and overflowing of ponds, and (vi) eutrophication or upwelling and harmful algal blooms resulting in fish kills, among others.

Geronimo (2018) identified potential effects of climate change on the populations of the top commercially exploited marine species in the country and projected that: (i) marine species will experience reductions in habitat suitability within the Philippine exclusive economic zone (EEZ) with continued climate change, with the magnitude of change varying across species; and (ii) climate change will also substantially reduce the total area within the Philippine EEZ that is suitable for growth of other species. This study also compared the potential changes in the distribution of 59 top commercial marine species by 2050s under two climate change scenarios. All 59 species will experience reductions in suitability of existing habitats and extent of suitable areas for growth and survival while eight of these species will encounter conditions beyond their current known occurrence range.

Campos and Bagarinao (2021) reported that climate stressors and risks to the sardine fishery will likely vary among the six major sardine fishing grounds in the country including southern Palawan and Zamboanga waters in the Sulu Sea, considering the differences in the drivers of primary production and vulnerability of communities. These include an intensification of upwelling, stronger stratification of the water column, a decrease in drying capacity, the relocation of fishers along the coast, increasing vessel safety concerns and a reduction in effective fishing days. All these challenges are further exacerbated by the overfished status of sardine stocks.

A study on the potential distribution of mackerel scad (*Decapterus macarellus*) in the South China Sea under future climate scenarios has indicate a reduction in suitable habitats, particularly under high-emission scenarios, with more gradual reductions under low-emission scenarios (Shen et al., 2025). Habitat loss is most pronounced in the northern South China Sea, while the central region is projected to see an expansion of suitable habitats.

Increasing concern about the potential impacts of climate change on Philippine fisheries have been documented (Santos et al. 2011; Muallil et al. 2014; Macusi et al. 2020), and the projected economic impact of climate change on marine capture fisheries in the Philippines (Suh and Pomeroy 2020). Macusi et al. (2020) indicated that the top five exposure factors for small pelagic fisheries were: coastal development (leading to habitat destruction), water quality, temperature changes, typhoons, and declining fish catch.

5.3.3. Current Governance to Address Fisheries Problems

The following is a list of national laws and policies on fisheries management, conservation and protection:

- **Republic Act 7160:** The Local Government Code of 1991 outlines the powers and functions of local government units in the Philippines which includes jurisdiction over the municipal waters, among others.
- **Republic Act 7586:** The National Integrated Protected Areas System Act of 1992 and Republic Act 11038 or the Expanded National Integrated Protected Areas System (E-NIPAS) Act of 2018 for the establishment and management of protected areas.
- **Executive Order 240 (1995):** Creating the Fisheries and Aquatic Resources Management Councils (FARMCs) in Barangays, Cities and Municipalities, their Composition and Functions.

- **Republic Act 8435:** The Agriculture and Fisheries Modernization Act of 1997 – which prescribes measures to modernize the agriculture and fisheries sectors in order to enhance their profitability.
- **Republic Act 8550:** An act providing for the development, management and conservation of fisheries and aquatic resources, integrating all laws pertinent thereto, and for other purposes. Otherwise known as the Philippine Fisheries Code of 1998 (signed into law on 25 February 1998).
- **Republic Act 9147:** Wildlife Resources Conservation and Protection Act of 2001 – to conserve and protect wildlife species and their habitats and to regulate the collection and trade of wildlife.
- **Executive Order 305 (2004):** Devolving to Municipal and City Government the Registration of Fishing Vessels below three (3) Gross Tonnage (GT).
- **Executive Order 154 (2013):** A National Plan of Action to Prevent, Deter and Eliminate IUU Fishing – the plan outlines priority actions that will address the ecological, biological and socioeconomic challenges posed by IUU fishing in a coordinated and integrated manner with collaboration between Philippine government departments and agencies.
- **Republic Act 10654 (2015):** An act to prevent, deter, and eliminate Illegal, Unreported and Unregulated (IUU) fishing, amending RA 8550, otherwise known as “The Philippine Fisheries Code of 1998”.

Philippine Fisheries Code of 1998 (RA 8550) provides a comprehensive legal framework that governs the development, management and conservation of the country’s fisheries and aquatic resources. The Fisheries Code focuses on the sustainability of the fishery resources and maintenance of ecological balance as well as achieving food security through a regulatory regime that operates through Local Government Units (LGUs) and FARMCs for municipal waters in collaboration with DA-BFAR for all fisheries and aquatic resources other than municipal waters. The Code enumerates the following objectives of the fishery sector: (1) conservation, protection and sustained management of the country's fishery and aquatic resources; (2) poverty alleviation and the provision of supplementary livelihood among municipal fishers; (3) improvement of productivity of aquaculture within ecological limits; (4) optimal utilization of offshore and deep-sea resources; and (5) upgrading of post-harvest technology.

The Amended Fisheries Code (RA 10654) put emphasis on the act to prevent, deter and eliminate IUU fishing. Accordingly, Section 2 of the Fisheries Code specifies that it is the policy of the state to achieve food security as the overriding consideration in the utilization, management, development, conservation and protection of fishery resources, in order to meet the nutritional needs of the population. A flexible policy towards the attainment of food security will be adopted in response to changes in demographic trends for fish, emerging trends in the trade of fish and other aquatic products in domestic and international markets, and the law of supply and demand.

The Fisheries Code (RA No. 8550 in 1998, as amended by RA No. 10654 in 2015) also recognizes the concept of integrated coastal area management in managing fishery and aquatic resources in natural fisheries management areas (Section 2f). Hence, BFAR Fisheries Office Order No. 164 (s. 2016) promotes EAF as the foundation for managing fisheries resources and provides guidelines to operationalize the EAF concept in the development and implementation of BFAR programs and activities.

The adoption of EAF in FMAs is an attempt to provide a framework to integrate national and local management roles, based on a common science-based platform and consistent with international best practices. The Fisheries Code gave BFAR a mandate to establish FMAs and adopt measures following an ecosystem-based approach. In 2019, BFAR formally delineated 12 FMAs under FAO 263 in order to “provide a science-based, participatory and transparent governance framework and mechanism to sustainably manage fisheries in such areas, consistent with the principles of EAF and anchored on food security and supplementary livelihood for poverty alleviation.”

The Local Government Code (LGC) of 1991 (RA 7160), is a landmark legislation wherein the government of the Philippines undertook policy and institutional reform to facilitate increased participation in management and to

devolve control over resource access to local levels of government. The resulting jurisdictional divisions designate authority to village, municipal or city governments for management of ‘municipal waters’ up to 15 km from the shoreline and resources within the territorial boundaries of these municipalities or cities. This law promotes local autonomy and government decentralization that devolved much authority to local government units (LGUs), specifically the municipal level. As such, the LGUs have become the key managers of natural resources within their territorial boundaries. This national law has provided for the devolution of the responsibilities in the provision of a number of basic services from National Government Agencies to the Local Government Units (LGUs). Among the responsibilities devolved to the LGUs are the enforcement of environment and natural resources laws within the territory of the LGUs, water and soil resources utilization and conservation projects. Specifically, the devolved responsibilities concerning the fisheries sector are the enforcement of fishery laws in municipal waters (i.e., within 15-km from shoreline) and the provision of extension and on-site research services and facilities related to agriculture and fishery activities.

The 2015 Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (The SSF Guidelines) (FAO 2015) is the first international instrument dedicated entirely to the small-scale fisheries sector. These are aimed at all actors striving to secure sustainable small-scale fisheries, to end hunger and poverty and strengthen human rights. In October 2024, the NPOA-SSF was officially launched by the Department of Agriculture – Bureau of Fisheries and Aquatic Resources (DA-BFAR) in partnership with FAO, local fisherfolk and various government, NGO and research partners. It was a result of a participatory and inclusive process that engaged stakeholders across the country in various Fisheries Management Areas (FMAs), including representatives from municipal and artisanal capture fisheries, Indigenous Peoples and vulnerable workers across the value chain, NGOs, national government authorities, research partners, among others.

5.3.3.1 Management and Conservation Efforts

The Comprehensive National Fisheries Industry Development Plan (CNFIDP) 2006–2025 was developed to provide a framework for promoting the optimal development and long-term sustainability of benefits derived by the nation from its fisheries. To attain the vision of a sustainable and competitive fisheries industry, the CNFIDP 2021–2025 identified the following important elements: (1) sufficient contribution to national food security; (2) inclusive growth within the industry; (3) sustainable, science-based fisheries and aquatic resource management practices; (4) compliance with international laws, policies and standards, and enforcement of local laws and regulations; (5) strengthened capacities in infrastructure, technologies, human resources and information-sharing; and (6) resilience to environmental hazards. BFAR in close collaboration with key stakeholders (including Fisheries and Aquatic Resources Management Councils) has also developed National Plan of Action (NPOA) for sardines, tuna, IUU Fishing, among others.

The Philippines has several programs to improve fisheries management using an EAFM and integrated coastal management approach that are conducted in collaboration with Local Government Units (LGUs) and non-government organizations (NGOs). Key strategies for fisheries management and conservation that are being implemented by BFAR, and are consistent with the CNFIDP include (BFAR 2021): (i) restoring fishery habitats (mangroves, seagrasses, coral reefs, wetlands and inland bodies of water) through protection and rehabilitation; (ii) protecting spawning grounds and spawning cycles based on research and participatory processes; (iii) delineating and zoning of coastal lands and water uses to resolve conflicting uses with the Comprehensive Land Use Plans (CLUPs); and (iv) developing and harmonizing inter-LGU coastal resources management plans based on participatory coastal resources appraisals, among others. BFAR has also undertaken fisher registration and boat registration, and improvements in management, monitoring and enforcement have been included in the Integrated Maritime Environmental Monitoring System (IMEMS) including deployment of BFAR Vessels to conduct MCS activities, as well as Vessel Monitoring System, and Catch Reporting/Documentation.

In early 2000, the National Fisheries Research and Development Institute (NFRDI), in collaboration with BFAR Regional Offices were mandated to monitor the status of fish stocks in major fishing grounds through the National Stock Assessment program (NSAP). Recently, NFRDI-NSAP started collating data at the FMA-level to provide science support to the development and implementation of FMA-based fisheries management plans for priority fish stocks.

The delineation of Philippine waters into 12 FMAs represents a significant shift for the country in the management of straddling and shared stocks (Ramiscal et al., 2024). And the FMAs provides a framework and mechanism for fisheries managers and resource users to move from an open access regime to nuanced management that takes into account the status of the stocks. The establishment of FMAs aims to facilitate a transition from geographic and production-based fisheries management to EAF, with the long-term goal of managing fish stocks in a more sustainable manner, while gaining greater economic benefits. The main features of the FMA concept are: (i) spatial delineation of Philippine waters as a means to manage resources at an appropriate scale; (ii) approximation of an ecosystem scale of management; (iii) approximation of stocks and fisheries distribution based on the best available science; and (iv) building on previous resource management interventions such as seasonal fishing bans or closed seasons, species-level management plans, and bay-wide management.

In 2024, BFAR initiated the implementation of the Fisheries and Coastal Resiliency (FishCoRe) Project. The development objective of FishCoRe is to improve the management of targeted fisheries resources and enhance the value of fisheries production to coastal communities in selected FMAs (i.e. FMAs 6 and 9). Specifically, key targets include fisheries management plans (FMPs) implemented in the FMAs; and the share of major fish stocks covered in FMPs including harvest control rules and measures moving towards target reference points, among others. Annex 5.B. provides the summary of the goals and objectives of the FMA 5 and 6 Framework Plans in support to sustainable fisheries management in the SCS LME.

In addition, BFAR in collaboration with local government units and fishing industry and has introduced temporal (seasonal) area-based closed fishing seasons for conservation sardines in the Zamboanga peninsula (including portions of FMA 5 in eastern Palawan) and Visayan Sea from November 15 to February 15; and round scad in northern Palawan waters within FMA 5 from November 1 to January 31 (BFAR, 2024). Similar policy interventions are encouraged to be implemented in FMA 5 and 6. While the policy's continuous implementation will conserve the fisheries resources and sustain the sardine industry, it should be complemented with regular and continuous monitoring of socioeconomic impact to provide information for feedback to reframe and revise for a more effective policy (Rola et al. 2020). For closed season to be effective it has to be applied along with other management strategies such as mesh size regulation, establishment of Marine Protected Areas, and provision of alternative sources of livelihood (Napata et al. 2020).

As part of the SCS Refugia project, a national plan of action (NPOA) for the establishment of "fisheries refugia" in the coastal areas of Masinloc in Zambales, Coron in Palawan and Bolinao in Pangasinan was developed (Garcia et al., 2022). The concept of fisheries refugia was developed as a novel approach to the identification and designation of priority areas in which to integrate fisheries and habitat management in the context of high and increasing levels of small-scale fishing pressure in the South China Sea (Paterson et al. 2013). In addition, the refugia concept also appears to be a successful approach in addressing a significant barrier to the integration of fisheries and habitat management, namely the adverse reaction to the Marine Protected Area concept that is elicited from fishing communities and fisheries officers at the local and provincial levels. And it is anticipated that the experiences gained from this novel approach to the use of spatial management tools in fisheries management will be suitable for scaling-up in the SCS region and replication in other aquatic habitats.

Building on from the SCS Refugia project (Paterson et al., 2013), the establishment and monitoring of the fisheries refugia in the coastal areas of Masinloc, Zambales, Coron, Palawan and Bolinao, Pangasinan must be pursued

and replicated (see Table 5.8 and Figure 5.9 below). BFAR through Fisheries Office Order No. 335 (FOO), approved the Implementation of the Guidelines on the Establishment and Operation of Fisheries Refugia in the Philippines”, and management plans for each refugia site has been developed by BFAR in collaboration with the LGUs.

Table 5.8. Description of Fisheries Refugia Sites in the Philippines (Borja et al., 2022).

Fisheries Refugia Sites	No. of Hectares (ha)	Priority Species	Type of Habitat	Habitat in Hectares (ha)
Bolinao, Pangasinan	99.8	<i>Siganids spp.</i>	Seagrass	1,084.58
Coron, Palawan	163.20	<i>Caesio cuning</i> <i>Decapterus muroadsi</i>	Mangrove	229.56
Masinloc, Zambales	120.69	<i>Pterocaesio tessellata</i> <i>Sadinella fimbriata</i>	Coral reef	1,602.20

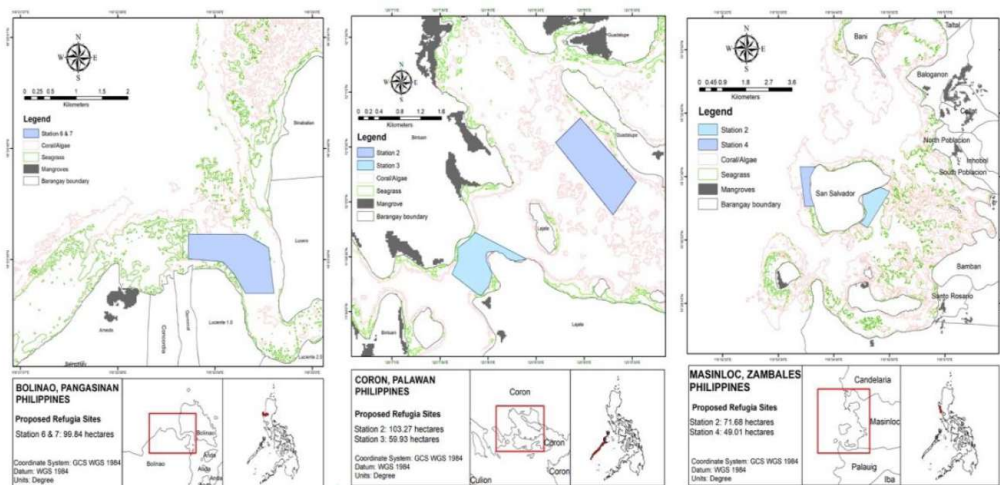


Figure 5.9. Map of Fisheries Refugia Sites in the Philippines (Borja et al., 2022)

5.3.3.2 Regional Cooperation

Table 5.9 below provides a list of regional fisheries cooperation mechanisms in the Asia Pacific region and the government of the Philippine are associated or member-country.

Table 5.9. List of regional fisheries collaboration and cooperation mechanisms for the Asia Pacific region (Adopted from USAID SuFiA TS 2024).

Institution / Organization	Primary Mandate
1. Association of South East Asian Nations (ASEAN)	Regional geo-political and economic organization of 10 countries that aims acceleration of economic growth, social progress, and cultural development among its members as well as the promotion of the region’s peace and stability. The ASEAN Network for Combating IUU Fishing (AN-IUU) was establish to: (i) enhance regional cooperation on information sharing through an online interactive platform; as well as on the use of Monitoring, control and Surveillance (MCS) information; and (ii) enhance capacities and capabilities of ASEAN Member States (AMS) in the fight against IUU fishing through the dissemination of best practices, especially on MCS and investigation activities and experiences.
2. Asia-Pacific Fishery Commission (APFIC)	APFIC was established under the APFIC agreement as the Indo-Pacific Fisheries Council in 1948 by the Food and Agriculture Organization of the United Nations (FAO). APFIC works to improve understanding, awareness and cooperation in fisheries issues in the Asia-Pacific region.

3. ASEAN Centre for Biodiversity	Intergovernmental organization in response to the challenge of biodiversity loss that facilitates cooperation and coordination among 10 ASEAN Member States and with regional and international organizations on the conservation and sustainable use of biological diversity and the fair and equitable sharing of benefits arising from the use of such natural treasures
4. Coordinating Body on the Seas of East Asia (COBSEA)	As a regional coordinating body under UNEP, it promotes the development and protection of the marine environment and coastal areas of East Asian Seas to support human well-being and livelihoods and contribute to sustainable development for the long-term benefit of present and future generations
5. Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI-CFF)	A multilateral partnership of the six Coral Triangle countries formed to sustain the marine and coastal resources by addressing crucial issues such as food security, climate change and marine biodiversity; also mandated to promote regional cooperation, sharing of lessons, and facilitate learning across the six countries.
6. Partnerships in Environmental Management for the Seas of East Asia (PEMSEA)	A regional coordinating mechanism for the sustainable development seas and coasts in East Asia that works together with countries, non-governmental organizations, local governments, academic institutions, and other development partners to foster and sustain healthy and resilient ocean, people, and economies across the region.
7. Regional Plan of Action to Promote Responsible Fishing Practices including to Combatting Illegal, Unreported, and Unregulated Fishing Practices in the Region (RPOA-IUU)	A high-level decision-making body providing strategic advice and direction to RPOA member countries about conservation of the marine environment, sustainable management of fisheries resources, managing fishing capacity, building competency in fisheries management, and combating IUU fishing in the region.
8. Southeast Asian Regional for Graduate Study and Research in Agriculture (SEARCA)	A non-profit R&D organization with a mandate to build capacities in agricultural and rural development in Southeast Asia; with current fisheries works related to climate change, impact assessments and vulnerabilities
9. Southeast Asian Fisheries Development Center (SEAFDEC)	An autonomous inter-governmental body with mission “To promote and facilitate concerted actions among the Member Countries to ensure the sustainability of fisheries and aquaculture in Southeast Asia”; primarily R&D mandate with learning and demonstration sites related to capture fisheries and aquaculture
10. WorldFish Center Penang Office	A global research and innovation institution in aquatic food systems that support sustainable development and food systems transformation for healthy and resilient diets with R&D works in the fisheries sector embedded in the larger aquatic food systems; FAO/UN on Southeast Asian/Indo-Pacific fisheries management and food security.

5.3.4 Recommended Priority Actions including those for Regional Cooperation

Zhang (2018) proposed three primary objectives for fisheries cooperation in SCS, namely, 1) achieving food security and economic development, 2) ensuring sustainable fishery and protecting marine environment, and 3) preventing fishing conflicts and disputes. Additionally, using these three objectives as evaluation criteria, three prevailing options for regional cooperation can be pursued, including (i) Marine Protected Areas (MPA)/Marine Peace Park, (ii) Regional Fishery Management Organizations (RFMO), and (iii) aquaculture.

On 16-18 January 20204, BFAR in partnership with the U.S. Agency for International Development (USAID) Sustainable Fish Asia Technical Support (SuFiA-TS) conducted a Regional Technical Exchange to: collaboratively strengthen sub-regional information exchange and policies; share relevant information from recent assessments and research in the sub-region; and identify priority needs for improving sub-regional information sharing and strengthening regional technical capacity and collaborative fisheries management mechanisms (USAID SuFiA TS 2024). Based on the technical report, the identified regional capacity building in support for improved fisheries

management in the SCS, as well as needs for regional fisheries data and information sharing include the following thematic areas (see Table 5.10): (1) fisheries management (FM), (2) Combined FM / Research and Development, (3) Research and Development, and (4) Data and Information Sharing (DIS), along with proposed initiatives to address the perceived gaps in regional capacity.

Table 5.10. List of regional capacity building needs for improving fisheries management in SCS including regional data and information sharing (USAID SuFiA TS, 2024).

Capacity	Perceived gaps in regional capacity	Proposed capacity building initiatives	Proposed lead
Fisheries Management (FM)	MCS: Fisheries surveillance and enforcement; community-based surveillance group	Collaborative enforcement; PSMA; training based on success stories in the region, i.e., Bantay-dagat (fish warden); fisheries intelligence training	ASEAN, CTI, RPOA-IUU
	Small-scale fishing operations		
	Disaster relief and response		
	Stock assessment and population dynamics for vulnerable species (e.g., marine mammals) Assessment models (translating Stock Assessment to management (advise)	ToT for Regional trainers (intensive online courses), for scientist; training program for fisherfolks/stakeholders;	SEAFDEC, CTI-CFF University partnership, ASEAN, Academe, and other RFMOs to be mainly supported by NOAA, Australian
	Destructive fishing gears		
FM/ Research and Development	Harvest Strategy; Management indicators and Reference Points, Assessment of fishing capacity		
	Capacity for Catch documentation		
	Managing compatibility and conflict between capture fisheries and aquaculture; stateless fishers		
Research and Development	Community engagement (communication and cooperation); incorporate traditional knowledge		
Data and information sharing (DIS)	Habitat assessment		
	Technology literacy (updated IEC)	Technology training/ demonstration; Training of Trainers; Language translation materials	CTI-CFF, ASEAN
	Data standardization and sharing;	It's complicated	

Significant data and knowledge gaps include: policy and governance, socioeconomics, information and data management infrastructure, capacity of small-scale fishers, and stock status. An enhancement of regional capacity is needed in monitoring, control and surveillance of small-scale operations, stock assessments and population dynamics, technology literacy, and harmonizing data standards to improve policy. Strengthening regional and international cooperation is paramount in marine capture fisheries management in South East Asia (DAFF, 2011). Such initiative may include strengthening capacity for complementary management of transboundary stocks, joint (and common) stock assessment, cooperative MCS and international engagement.

In 2018, the Centre for Humanitarian Dialogue (HD), a private diplomacy organization founded to prevent, mitigate and resolve armed conflicts and crises through dialogue and mediation, began facilitating a multilateral dialogue amongst scientists and policymakers from China, Indonesia, Malaysia, the Philippines and Vietnam, aimed at reducing regional tensions (Prince et al., 2022). By establishing an informal Fisheries Science Working Group

(FSWG), the FSWG) has convened eight times between 2018 and 2022, and benefiting from a wide range of independent expertise, the participating fisheries managers, diplomats, and national security officials discussed cooperatively managing SCS fisheries resources, and decided to begin by building the basis of regional scientific consensus around the status and management of some key fisheries. The FSWG agreed to a process involving multi-lateral scientific cooperation through a series of Common Fisheries Resource Analyses (CFRA) adhering to agreed principles of: (i) Voluntary participation, (ii) Focus on issues relevant to policymakers across the region, (iii) Allowing all participating countries to contribute meaningfully and on an equal footing, (iv) Avoiding territorial disputes and other political sensitivities, and (v) Not requiring the sharing of raw data or other sensitive information. The CFRA processes was facilitated by HD which provided secretariat support, access to independent technical expertise, meeting facilitation and modest funding for new data collection where necessary. The conclusion of the study indicated that fishing targeted at adult stocks would probably be sustainable, but for the continuing intensification of fishing for juveniles skipjack tuna stocks, and fishing pressure is apparently eroding SCS food webs and serially depleting local stocks” (Prince et al., 2023).

Marine scientific research (MSR) is essential in addressing these challenges by providing the scientific evidence needed to develop sustainable conservation strategies, guide policy decisions, and foster regional cooperation (Mallari et al. 2025). In the Philippines, the lack of a national MSR agenda limits the promotion of the conduct of MSR and provides a plan of action on ensuring its translation into policies. As the region moves toward policy solutions, the challenge lies in leveraging MSR for effective and cooperative management within the Philippine waters in the SCS LME and in the larger South China Sea, ensuring long-term ecological health and socioeconomic stability.

Additionally, Ablan-Lagman (2017) suggested the following actions for the Philippines to advance our own fisheries management policy, in connection with our neighbors in the SCS: (i) establish transboundary marine parks or areas of joint protection (e.g., marine areas that serve as refuge, sources or sinks of fish juveniles and larvae); (ii) bring into discussions other international policy instruments (e.g., FAO Code of Conduct for Responsible Fisheries of (1995); Agreement Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (1995); and (iii) develop regional-level policies targeted toward small-scale fisheries (noting the Philippines has already developed its NPOA SSF in 2024 following the FAO SSF guidelines).

5.4 Methodology and Analysis

The guidelines to support the drafting of the national TDA using identified fish and fisheries indicators was followed. Fisheries production data for the period 1950-2016 compiled by the Sea Around Us project (<https://www.seaaroundus.org/>) for Philippine waters in the SCS LME was provided by the Regional Fisheries Consultant. This was complemented with the fisheries statistics data obtained from the Philippine Statistics Authority. Data and reports from NFRDI - NSAP was used for assessing stock status and number of fishing boats were derived from BFAR annual fisheries profiles. Marine trophic index (MTI), Fishing-in-Balance (FIB) index and primary production required (ecological footprint of fisheries) were obtained from SAUP data for the Philippines. In the preparation of this report online and published sources of information were also used and these sources are listed in the references (Table 5.11). Below are the fisheries indicators and data sources.

Table 5.11. Fisheries indicators and data sources.

Indicator	Data sources
Fisheries Production Potential	PSA data 1980-2024 by subsector, by province, and SAUP data (fish catch, fishing gear, species composition; Sea Around Us project data https://www.seaaroundus.org/)
Stock Status, Biomass	NSAP reports/data (selected key pelagic species); other reports and publications
Fishing Effort	BFAR annual Fisheries Profiles

PPR, MTI, FIB	SAUP data complemented by Sea Around Us report for Philippines (Palomares et al. 2014)
Catch from bottom impacting gear types	Reports for Manila Bay and Lingayen Gulf other reports and publications
Change in catch potential under climate change	Limited information; used report on “Projected Climate Change Impacts on Philippine Marine Fish Distributions” complemented by published reports

This report was initially validated with BFAR on 3 November 2025 and presented during the National Validation Workshop on 12-14 November 2025. Comments and suggestions by key stakeholder on the draft Fisheries report were considered and included in the finalization of this report. Table 5.12 provides proposed interventions to improve fisheries data collection and analysis, as well as strengthening fisheries law enforcement.

Table 5.12. List of proposed interventions to improve fisheries data collection and analysis, and fisheries law enforcement.

Proposed Interventions	Indicative Lead Agencies
Unified data collection form for fish catch monitoring Data Consolidation/Reconciliation Data Analytics and Data sharing	DA-BFAR/PSA/DA-NFRDI
Catch documentation and reporting systems	DA-BFAR/LGUs
Study on the impacts of IUU fishing activities within Philippines fishing areas including coastal habitat assessments	DA-BFAR/DENR, Academe/NGOs
Enhanced Stock Assessments by FMA/fishing areas	DA-NFRDI/DA-BFAR, Academe/NGOs
Unified and centralized database for enforcement reports (apprehensions/violations) and list of registered and licensed fishing boats/vessels	DA-BFAR, PNP Maritime (within 12 nm)/Coast Guard (beyond 15 km), LGUs (within 15 km)

Glossary

- **Ecosystem Approach to Fisheries Management** – An approach to fisheries management and development that strives to balance diverse societal objectives by considering the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions, applying an integrated approach to fisheries within ecologically meaningful boundaries. An EAFM is a practical way to implement sustainable development for the management of fisheries by finding a balance between ecological and human well-being through good governance. The purpose of EAFM is to plan, develop, and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems (Garcia et al. 2003; Food and Agriculture Organization 2003, 2011).
- **Fishing-in-Balance (FiB) index** - aim to account for the expansion and contraction of fishing fleets over time as reflected by the trophic level of the catches.
- **Fisheries Management Area** - delineated bodies of water in the Philippines based on approximation of fish stocks and their boundary, range and distribution and other considerations for the purpose of fisheries management or governance that is science-based, participatory and transparent, applying the ecosystem approach to fisheries management (EAFM). FMA provides a framework to integrate national and local management roles, based on a common science-based platform and consistent with international best practices.
- **Fisheries Management**– An integrated process to improve the benefits that society receives from harvesting fish consisting of (i) information gathering, (ii) analysis, (iii) planning, (iv) consultation, (v) decision making, (vi) allocation of resources, and (vi) formulation and implementation—with enforcement as necessary—of

regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives.

- **Fisheries Refugia** – concept as a fisheries management tool has been introduced in the Southeast Asian region with the objective of enhancing fisheries resources through the integration of fisheries and habitat management. The concept is defined as “spatially and geographically defined, marine or coastal areas in which specific management measures are applied to sustain important species [fisheries resources] during critical stages of their life cycle.” (Siriraksophon, 2016)
- **Marine Trophic Index (MTI)** - measures the change in mean trophic level of fisheries catches from an ecosystem, adequately tracks changes in mean trophic level of an ensemble of exploited species in response to fishing pressure.
- **Primary Production Required (PPR)** index - is a crucial tool for evaluating the ecological footprint of fisheries. It provides a comprehensive understanding of the impacts of fishing activities on marine ecosystems and facilitates sustainable fishery management.

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Author Contributions

The Author was responsible in the conceptualization, literature review, data collection, collation and analysis, writing the report, review and editing based on the guidelines to support the drafting of the national TDA using identified fish and fisheries indicators.

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Chapter 5 Annexes

Annex 5.A. Key Biological Parameters of Major Fish Species in FMA 5 and 6

Table 5.A.1. Growth, mortality parameters and exploitation rates of different species caught in FMA 5 and 6 fishing grounds of the Philippines (Adopted from Silvestre et al., 2003).

Species	Fishing Ground	FMA	Year	L_{inf}	k	L_c	Z	M	F	E	Source
<i>Ambassis gymnocephalus</i>	Manila Bay	6	1978-79	19.5	1.2	10.6	5.24	2.27	2.97	0.57	Ingles & Pauly, 1984
<i>Atule mate</i>	Manila Bay	6	1992-93	27	0.7		5.3		3.82		Armada, 1994
<i>Atule mate</i>	Lingayen Gulf	6	1987-88	24.9		10.05		.48		.72	Ochavillo et al. 1989
<i>Cynoglossus puncticeps</i>	Manila Bay	6	1978-79	24.5	.65	7.8	3.29	1.43	1.86	0.57	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Manila Bay	6	1957-58	1.5	0.65	19.2	3.74	1.33	2.41	0.64	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Manila Bay	6	1958	1.5	0.71	16.5	3.8	1.41	2.39	0.63	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1957	27	0.9	15.3	4.01	1.72	2.29	0.57	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1957-58	26.8	0.71	16.7	4.71	1.47	3.24	0.69	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1958	26.5	1	19.2	6.86	1.85	5.01	0.73	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1958-59	27.8	0.83	19.5	6.46	1.61	4.85	0.75	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1960	33	0.5	17.7	4.8	1.1	3.7	0.77	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1960	27.5	1.25	16.6	10.5	2.12	8.38	0.8	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1965	25	1.2	13.9	11.57	2.12	9.45	0.82	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1965-66	25.5	0.85	16.6	4.14	1.68	2.46	0.59	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1966	25.5	0.8	13.3	5.26	1.62	3.64	0.69	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1968	33	0.65	17.5	3.38	1.31	2.07	0.61	Ingles & Pauly, 1984
<i>Decapterus macrosoma</i>	Palawan	5	1968b	30	0.74	19.5	5.79	1.47	4.32	0.75	Ingles & Pauly, 1984
<i>Decapterus russelli</i>	Manila Bay	6	1958-59	27	0.8	16.8	6.89	1.59	5.3	0.77	Ingles & Pauly, 1984
<i>Decapterus russelli</i>	Manila Bay	6	1959	30	0.54	15.4	2.06	1.19	0.87	0.42	Ingles & Pauly, 1984
<i>Decapterus russelli</i>	Palawan	5	1958	26.9	0.69	15.6	4.34	1.44	2.9	0.67	Ingles & Pauly, 1984
<i>Decapterus russelli</i>	Palawan	5	1959	26	0.73	18.2	3.69	1.51	2.18	0.59	Ingles & Pauly, 1984
<i>Decapterus russelli</i>	Palawan	5	1968	33	0.45	15.4	2.62	1.03	1.59	0.61	Ingles & Pauly, 1984
<i>Dussumiera acuta</i>	Lingayen Gulf	6	1987-88	18	1.3	12.92	6.72	2.44	4.28	0.64	Ochavillo et al. 1989
<i>Gazza acclamys</i>	Lingayen Gulf	6	1987-88	12.8	1.17	6.71	5.91	2.51	3.4	0.58	Ochavillo et al. 1989
<i>Gazza minuta</i>	Honda Bay	5	1977-78	17.5	0.97	8.6	6.62	2.03	4.59	0.69	Ingles & Pauly, 1984
<i>Gazza minuta</i>	Lingayen Gulf	6	1987-88	11.8	1.17	8.95	3.64	2.57	1.07	0.29	Ochavillo et al. 1989
<i>Gerres filamentosus</i>	Manila Bay	6	1992-93	18.3	0.9		5.34	1.95	3.39	0.63	Armada, 1994
<i>Hemirhamphus georgii</i>	Manila Bay	6	1978-79	34.5	0.6	15.3	2.32	1.23	1.09	1.47	Ingles & Pauly, 1984
<i>Katsuwonus pelamis</i>	Sulu Sea	5	1975-76	83	0.78	54.7	6.57	1.14	5.43	0.83	Ingles & Pauly, 1984
<i>Leiognathus bindus</i>	Manila Bay	6	1958	10.3	1.25	4.5	6.7	2.79	3.91	0.58	Ingles & Pauly, 1984
<i>Leiognathus bindus</i>	Manila Bay	6	1959	8.2	1.25	4.1	4	2.97	1.03	0.26	Ingles & Pauly, 1984
<i>Leiognathus bindus</i>	Manila Bay	6	1960	8.2	1.3	3.4	4.58	3.05	1.53	0.34	Ingles & Pauly, 1984
<i>Leiognathus bindus</i>	Manila Bay	6	1992-93	10.5	1.1		4.97	2.59	2.38	0.48	Armada, 1994
<i>Leiognathus bindus</i>	Lingayen Gulf	6	1987-88	12.3	1.05	4.69	6.87	2.37	4.5	0.66	Ochavillo et al. 1989

<i>Leiognathus blochii</i>	Manila Bay	6	1957	13.2	1.2	5.2	5.05	2.53	2.52	0.5	Ingles & Pauly, 1984
<i>Leiognathus blochii</i>	Manila Bay	6	1958	12.5	1.16	6.1	4.32	2.51	1.81	0.42	Ingles & Pauly, 1984
<i>Leiognathus blochii</i>	Manila Bay	6	1959	12.5	1.25	6.4	4.51	2.64	1.87	0.41	Ingles & Pauly, 1984
<i>Leiognathus blochii</i>	Manila Bay	6	1959-60	12.5	1.25	6.4	5.6	2.64	2.96	0.53	Ingles & Pauly, 1984
<i>Leiognathus daura</i>	Manila Bay	6	1957	9.4	2.1	6.6	9.53	4.01	5.52	0.58	Ingles & Pauly, 1984
<i>Leiognathus daura</i>	Manila Bay	6	1959	9.6	1.27	6.3	6.73	2.87	3.86	0.57	Ingles & Pauly, 1984
<i>Leiognathus daura</i>	Manila Bay	6	1959-60	9.6	1.25	6.6	7.91	2.84	5.07	0.64	Ingles & Pauly, 1984
<i>Leiognathus equulus</i>	Manila Bay	6	1992-93	12	1.1		4.01	2.5	1.51	0.38	Armada, 1994
<i>Leiognathus equulus</i>	Lingayen Gulf	6	1987-88	19	1.3	7.68	4.05	2.41	1.64	0.4	Ochavillo et al. 1989
<i>Leiognathus leuciscus</i>	Manila Bay	6	1957	11.8	1.3	8.2	7.17	2.72	4.45	0.62	Ingles & Pauly, 1984
<i>Leiognathus leuciscus</i>	Manila Bay	6	1958	10.8	1.3	8.2	7.42	2.79	4.63	0.62	Ingles & Pauly, 1984
<i>Leiognathus lineolatus</i>	Manila Bay	6	1957	11.5	1.05	7.1	9.53	2.41	7.12	0.75	Ingles & Pauly, 1984
<i>Leiognathus lineolatus</i>	Manila Bay	6	1958	11.5	1.3	7.1	9.23	2.77	6.46	0.7	Ingles & Pauly, 1984
<i>Leiognathus lineolatus</i>	Manila Bay	6	1959	10	1.3	7.1	3.48	2.88	0.6	0.17	Ingles & Pauly, 1984
<i>Leiognathus splendens</i>	Manila Bay	6	1957-58	12.4	0.75	3.8	3.85	1.89	1.96	0.51	Ingles & Pauly, 1984
<i>Leiognathus splendens</i>	Manila Bay	6	1958	13.2	0.76	6.2	7.52	1.88	5.64	0.75	Ingles & Pauly, 1984
<i>Leiognathus splendens</i>	Manila Bay	6	1959-60	12.3	0.7	4.9	4.46	1.81	2.65	0.59	Ingles & Pauly, 1984
<i>Leiognathus splendens</i>	Manila Bay	6	1979-80	15	0.72	8.7	3.77	1.76	2.01	0.53	Ingles & Pauly, 1984
<i>Leiognathus splendens</i>	Lingayen Gulf	6	1987-88	11.6	0.79	7.17	2.59	2	0.59	0.23	Ochavillo et al. 1989
<i>Liza subviridis</i>	Manila Bay	6	1978-79	36.5	0.63	11.2	3.19	1.25	1.94	0.61	Ingles & Pauly, 1984
<i>Mene maculata</i>	Manila Bay	6	1978	22.5	1.22	15	3.85	2.2	1.65	0.43	Ingles & Pauly, 1984
<i>Mugil cephalus</i>	Manila Bay	6	1992-93	30	1.35		6.49	2.21	4.28	0.66	Armada, 1994
<i>Nematolosa nasus</i>	Manila Bay	6	1992-93	25	1.15		3.47	2.09	1.38	0.4	Armada, 1994
<i>Nemipterus japonicus</i>	Manila Bay	6	1978-79	30	0.7	14.8	3.31	1.41	1.9	0.57	Ingles & Pauly, 1984
<i>Nemipterus japonicus</i>	Manila Bay	6	1992-93	25.5	0.9		3.49	1.77	1.72	0.4	Armada, 1994
<i>Nemipterus japonicus</i>	Lingayen Gulf	6	1987-88	26.7	0.46	8.26	3.99	1.11	2.88	0.72	Ochavillo et al. 1989
<i>Nemipterus nematophorus</i>	Lingayen Gulf	6	1980-81	22	0.43	11.7	1.48	1.12	0.36	0.24	Ingles & Pauly, 1984
<i>Nemipterus nematophorus</i>	Lingayen Gulf	6	1987-88	27	0.62	8.28	7.15	1.35	5.8	0.81	Ochavillo et al. 1989
<i>Pelates quadrilineatus</i>	Manila Bay	6	1992-93	21	0.45		3.83	1.19	2.64	0.69	Armada, 1994
<i>Pennahia macrophthalmus</i>	Manila Bay	6	1978-79	26.5	1.4	13.1	5.55	2.3	3.25	0.58	Ingles & Pauly, 1984
<i>Pentaprion longimanus</i>	Lingayen Gulf	6	1987-88	13.7	1.05	6.26	5.34	2.29	3.05	0.57	Ochavillo et al. 1989
<i>Pomadasys argyreus</i>	Manila Bay	6	1958	13.6	0.78	8	3.9	1.88	2.02	0.52	Ingles & Pauly, 1984
<i>Pomadasys argyreus</i>	Manila Bay	6	1959	14.2	0.83	7.4	5.08	1.93	3.15	0.62	Ingles & Pauly, 1984
<i>Pomadasys argyreus</i>	Manila Bay	6	1960	15.1	0.62	8.1	4.5	1.57	2.93	0.65	Ingles & Pauly, 1984
<i>Pomadasys argyreus</i>	Manila Bay	6	1961	12.9	0.81	7.5	3.94	1.94	2	0.51	Ingles & Pauly, 1984
<i>Rastrelliger brachysoma</i>	Manila Bay	6	1978-79	34	1.1	15.2	4.27	1.84	2.43	0.57	Ingles & Pauly, 1984
<i>Rastrelliger brachysoma</i>	Manila Bay	6	1992-93	25.5	1		3.83	1.9	1.93	0.5	Armada, 1994
<i>Rastrelliger brachysoma</i>	Lingayen Gulf	6	1987-88	25		14.27	5.23	1.88	3.35	0.64	Ochavillo et al. 1989
<i>Rastrelliger kanagurta</i>	Palawan	5	1965	28	1.55	19.3	8.27	2.43	5.84	0.71	Ingles & Pauly, 1984
<i>Rastrelliger kanagurta</i>	Manila Bay	6	1992-93	24.5	0.85		4.96	1.73	3.23	0.65	Armada, 1994

<i>Sardinella fimbriata</i>	Manila Bay	6	1959	18	0.7	10.4	3.38	1.63	1.75	0.52	Ingles & Pauly, 1984
<i>Sardinella fimbriata</i>	Palawan	5	1965	22	1.15	14.7	6.56	2.12	4.44	6.56	Ingles & Pauly, 1984
<i>Sardinella fimbriata</i>	Manila Bay	6	1992-93	16.5	0.8		3.6	1.85	1.75	0.49	Armada, 1994
<i>Sardinella longiceps</i>	Manila Bay	6	1979	21	1.1	13.5	7.37	2.1	5.27	0.72	Ingles & Pauly, 1984
<i>Sardinella longiceps</i>	Palawan	5	1965	23	1.1	16.8	7.26	2.05	5.21	0.72	Ingles & Pauly, 1984
<i>Sardinella melanura</i>	Honda Bay	5	1978	22.5	0.7	18.8	3.36	1.53	1.83	0.54	Ingles & Pauly, 1984
<i>Sardinella sirm</i>	Palawan	5	1959	27.3	0.86	17.9	5.36	1.66	3.7	0.69	Ingles & Pauly, 1984
<i>Saurida tumbil</i>	Manila Bay	6	1978-79	37.5	1.03	18.1	4.83	1.71	3.12	0.65	Ingles & Pauly, 1984
<i>Saurida tumbil</i>	Lingayen Gulf	6	1987-88	39	0.52	7.97	3.33	1.08	2.25	0.68	Ochavillo et al. 1989
<i>Scatophagus argus</i>	Manila Bay	6	1978-79	25	1.2	14	4.12	2.12	2	0.49	Ingles & Pauly, 1984
<i>Secutor insidiator</i>	Manila Bay	6	1957	10.2	1.5	6	10.7	3.13	7.57	0.71	Ingles & Pauly, 1984
<i>Secutor insidiator</i>	Manila Bay	6	1959	11	1.35	6.5	5.31	2.88	2.43	0.46	Ingles & Pauly, 1984
<i>Secutor insidiator</i>	Manila Bay	6	1960	9.1	1.4	7.5	5.04	3.1	1.94	0.38	Ingles & Pauly, 1984
<i>Secutor insidiator</i>	Manila Bay	6	1992-93	12.5			5.01	2.32	2.69	0.54	Armada, 1994
<i>Secutor ruconius</i>	Manila Bay	6	1957	8.4	1.55	4.7	9.57	3.39	6.18	0.65	Ingles & Pauly, 1984
<i>Secutor ruconius</i>	Manila Bay	6	1959	9.2	1.15	4.8	8.69	2.72	5.97	0.69	Ingles & Pauly, 1984
<i>Secutor ruconius</i>	Manila Bay	6	1960	7.6	1.6	5.5	10.35	3.56	6.79	0.66	Ingles & Pauly, 1984
<i>Selar crumenophthalmus</i>	Manila Bay	6	1978-79	36.5	0.89	17.9	2.91	1.57	1.34	0.46	Ingles & Pauly, 1984
<i>Selaroides leptolepis</i>	Manila Bay	6	1978-79	29	0.8	11	2.76	1.56	1.2	0.44	Ingles & Pauly, 1984
<i>Selaroides leptolepis</i>	Manila Bay	6	1976-77	23	1.15	13.8	8.64	2.11	6.53	0.76	Ingles & Pauly, 1984
<i>Selaroides leptolepis</i>	Manila Bay	6	1992-93	25.5	0.95		3.26	1.84	1.42	0.44	Armada, 1994
<i>Sillago sihama</i>	Manila Bay	6	1978-79	23.5	0.7	11.9	2.7	1.51	1.19	0.44	Ingles & Pauly, 1984
<i>Sillago sihama</i>	Manila Bay	6	1992-93	25.5	0.75		4.68	1.57	3.11	0.66	Armada, 1994
<i>Stolephorus bataviensis</i>	Manila Bay	6	1992-93	13	1.05		6.68	2.37	4.31	0.65	Armada, 1994
<i>Stolephorus commersoni</i>	Manila Bay	6	1992-93	13	0.95		4.04	2.22	1.82	0.45	Armada, 1994
<i>Stolephorus commersonii</i>	Manila Bay	6	1961	11.3	0.96	8.07	4.94	2.28	2.66	0.54	Ingles & Pauly, 1984
<i>Stolephorus heterolobus</i>	Manila Bay	6	1961	11.4	0.95	7.58	10.69	2.29	8.4	0.79	Ingles & Pauly, 1984
<i>Stolephorus indicus</i>	Manila Bay	6	1957-58	16.3	1.42	11.7	5.81	2.67	3.14	0.54	Ingles & Pauly, 1984
<i>Stolephorus indicus</i>	Manila Bay	6	1958	15.7	1.08	12.2	4.53	2.23	2.3	0.51	Ingles & Pauly, 1984
<i>Stolephorus indicus</i>	Manila Bay	6	1992-93	14	0.8		4.7	1.94	2.76	0.59	Armada, 1994
<i>Stolephorus zollingeri</i>	Manila Bay	6	1957	10.1	1.1	7.48	8.41	2.55	5.86	0.7	Ingles & Pauly, 1984
<i>Stolephorus zollingeri</i>	Manila Bay	6	1958	10.6	1.85	7.2	12	3.53	8.47	0.71	Ingles & Pauly, 1984
<i>Stolephorus zollingeri</i>	Manila Bay	6	1961	9.2	1.15	6.8	4.22	2.69	1.53	0.36	Ingles & Pauly, 1984
<i>Therapon jarbua</i>	Manila Bay	6	1992-93	26	1		4.89	1.89	3	0.61	Armada, 1994
<i>Therapon theraps</i>	Manila Bay	6	1978-79	34	0.61	9.6	3.49	1.25	2.24	0.64	Ingles & Pauly, 1984
<i>Thyrssa setirostris</i>	Manila Bay	6	1992-93	17.5	1.1		6.14	2.25	3.89	0.63	Armada, 1994
<i>Thunnus albacares</i>	Sulu Sea	5	1975-76		0.42	52	2.06	0.65	1.41	0.68	Ingles & Pauly, 1984
<i>Trichiurus haumela</i>	Manila Bay	6	1992-93	90	0.7		3.52	1.06	2.46	0.7	Armada, 1994
<i>Trichiurus haumela</i>	Lingayen Gulf	6	1987-88	68.1	0.38	22.52	2.62	0.75	1.87	0.71	Ochavillo et al. 1989
<i>Trichiurus lepturus</i>	Manila Bay	6	1978-79	78	0.7	38.2	2.97	1.08	1.89	0.64	Ingles & Pauly, 1984

<i>Trichiurus lepturus (f)</i>	Manila Bay	6	1960-61	66	0.46	32.3	3.46	0.86	2.6	0.75	Ingles & Pauly, 1984
<i>Trichiurus lepturus (m)</i>	Manila Bay	6	1960-61	64.5	0.41	32.1	2.29	0.8	1.49	0.65	Ingles & Pauly, 1984
<i>Upeneus sulphureus</i>	Manila Bay	6	1992-93	17			6.5	2.13	4.37	0.67	Armada, 1994
<i>Upeneus sulphureus</i>	Lingayen Gulf	6	1987-88	19.9	1.32	8.88	8.72	2.4	6.32	0.72	Ochavillo et al. 1989
<i>Upeneus vittatus</i>	Manila Bay	6	1978-79	24.5	0.71	12.5	5.18	1.51	3.67	0.71	Ingles & Pauly, 1984
<i>Valamugil seheli</i>	Manila Bay	6	1992-93	23	1		6.83	1.96	4.87	0.71	Armada, 1994

Annex 5.B. Summary of Goals and Objectives of FMA 5 and 6

Table 5.B.1. Summary of Goals and Objectives of approved FMA Framework Plans for FMA 5 and 6. Adopted from BFAR FMA 5 (2023) and BFAR FMA 6 (2023).

Goals	Objectives
Fisheries Management Area 5	
1) Improved catch rate within sustainable limits	<ul style="list-style-type: none"> a) Catch of round scads (<i>Decapterus spp</i>) and tuna trending towards within target reference points by 2027, consistent with approved management plan; b) Establish reference points and stock status of other priority species by 2023; c) Adopt management measures for grouper and lobster by 2024; d) Reduce catching of immature fish sizes by 10% in 5 years; and e) Boost aquaculture production by 20% for 5 years to augment the demand for food fish and lessen pressure in capture fisheries.
2) Systematically conserve coastal habitats	<ul style="list-style-type: none"> a) Assist LGUs/ Alliances to establish MPA Networks covering 15% of coastal municipal waters based on systematic conservation planning by 2027; b) Improved coordinated protection of critical habitat by year 2024; c) By 2023, Database of critical habitat in FMA 5 is established, well-maintained and updated.
3) Improved economic security, resilience and welfare of coastal communities	<ul style="list-style-type: none"> a) 25% increased income of at least 25% registered fisherfolk living below poverty threshold in FMA 5 by 2027; b) Increase awareness & advocacy of stakeholders by year 2027,
4) Mainstream equitable access to economic opportunities	<ul style="list-style-type: none"> a) By 2027, a financial literacy program for fisherfolk will be established and sustained; b) By 2027 at least 25% of registered fisherfolk will receive livelihood support; c) By 2027 at least 5 types of fishing livelihood support will be provided to 25% of registered fisherfolk.
5) Reduced FMA-wide reported and/or actual occurrence of IUU Fishing Activities	<ul style="list-style-type: none"> a) To strengthen collaboration of national government agencies and all LGUs concerned on fishery law enforcement by 2023; b) Strengthen functionality and effectiveness of <i>bantay-dagats</i> through IATF-IUU fishing by 2024; c) Increase the number of LGUs with reviewed & updated MFO (based on R.A 10654) by 80% by year 2025 and 100% by 2027; d) Consult and adopt voluntary compliance principles and plans for CFVs by 2024. e) Establish coordination mechanisms with national agencies to address poaching by foreign fishing fleets.
6) Establish effective institutions for fisheries management	<ul style="list-style-type: none"> a) By 2025, establish and/or strengthen LGU alliances as platforms for cooperation in implementation of management actions; b) Prepare a Joint Administrative Order between BFAR, DENR, and DILG for Local Government Units to adopt FMA Framework Plan for all coastal communities/cities within FMA 5; c) Allocate 100% increase of the LGUs budget for fisheries management by 2024;

- d) Enhance fisheries program, activities, and project assessment and monitoring system by 2024;
- e) Strengthening of Fisheries Management Area 5 - Bodies (Management Board, Technical Working Group, Scientific Advisory Group, and Secretariat by 2023;
- f) Create and maintain fisheries database system for FMA 5 by year 2025.

Goals	Objectives
Fisheries Management Area 6	
1. Restored fish stocks at sustainable level	<ul style="list-style-type: none"> a) By 2023, reference points are established and harvest control rules (HCR) are agreed; b) By 2024 and succeeding years, management actions are based on science or recommendations of stock assessments and/or species specific EAFM plans developed and implemented; c) By 2027, priority fish stocks identified in West Philippine Sea and Manila Bay managed towards target reference points and agreed HCRs; d) By 2027, restored fishery habitats (coral reefs, seagrass, mangroves and inland bodies of water) through marine protected areas and fish sanctuary and their continuing conservation/rehabilitation with at least one network/cluster per province.
2. Compliant fishers and harmonious fishing communities	<ul style="list-style-type: none"> a) By 2027, deter, prevent/eliminate/reduce by at least 5% IUU Fishing by promoting compliance to fishery rules and regulations
b) Knowledgeable fisherfolks provided with enabling environment for sustainable livelihood and improved benefits from fisheries	<ul style="list-style-type: none"> a) By 2027, 70-80% of the fisherfolk are knowledgeable on various fishery programs b) By 2027, each region has supported and capacitated at least 20-30% of all fisherfolk organization including women-led enterprises in aspects of financial literacy, sustainable fisheries, etc. c) By 2027, developed and demonstrated the full potential of top aquaculture fishery commodities contributing to enhanced food security d) By 2027, established at least two network in FMA 6 with infrastructures for priority aquaculture commodities as livelihood support/option for fisherfolks e) By 2027, fisherfolks are engaged in sustainable fisheries with 3% increase in household income
c) Improved markets of fisheries and aquatic commodities established	<ul style="list-style-type: none"> a) By 2026, fair market price along the supply chain established b) By 2030, 80% increase in market accessibility and enable smallholders negotiate with larger business or market development c) By 2030, post-harvest losses reduced by 3% by creating an enabling environment d) By 2030, elevated value and quality of products
d) Mechanisms in place to address resource use conflicts towards equitable access and use of fisheries resources	<ul style="list-style-type: none"> a) By 2023 and succeeding years, strengthen and institutionalize linkages and networks among stakeholders through collaborative meetings and events

	<ul style="list-style-type: none"> b) By 2025, functional communication platform for the whole FMA 6 to strengthen the linkages among stakeholders and support FMA implementation, monitoring and evaluation c) By 2027, strengthen fisheries / coastal resource management (CRM) with at least 20% of LGUs adopting the FMA Framework Plan d) By 2027, harmonize zonation on municipal waters with roll-out to concerned LGUs e) By 2027, 50% of municipal waters of coastal and inland municipalities/cities are assisted
e) Adequate and capacitated institutions and stakeholders in fisheries governance	<ul style="list-style-type: none"> a) By 2023 and continuous thereafter, increase human technical capabilities of LGUs, NGAs, stakeholders and local civic society organization relevant to fisheries management b) By 2027, capacitated 50% of identified LGUs/ stakeholder groups that need training or capacity building
f) Adequate and capacitated institutions and stakeholders in fisheries governance	<ul style="list-style-type: none"> a) By 2023 and continuous thereafter, increase human technical capabilities of LGUs, NGAs, stakeholders and local civic society organization relevant to fisheries management b) By 2027, capacitated 50% of identified LGUs/stakeholder groups that need training or capacity building

**“Been there, done that, and yet things have gotten worse somewhat”
An Update on the Philippine Coastal and Marine Policy and Governance Set-up**

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Abstract

The Philippines from the year 2000 to 2023 has shown an unsteady economic growth pattern even if it still fared comparatively well vis-à-vis the global trend. Notwithstanding this, a well-developed set of policies, institutions, regulatory agencies, and administrative arrangements were implemented through the NTDA 1.0 recommendations on pollution and water-related issues, aquatic and marine resources conservation and sustainable utilization and the integration of land care and coastal management, with the exception of the establishment and strengthening of legal and institutional support for integrated watershed management systems, enhanced management of the surface and groundwater resources and the prioritization of water conservation and the regeneration of degraded water reservoirs. Through the years, the Philippines has steadily taken on commitments under various international agreements on fisheries, biodiversity, marine pollution, climate change and the UN process on the Sustainable Development Goals (SDGs) while also engaging actively with various transboundary governance arrangements in Southeast Asia. In spite of these established institutional frameworks and arrangements, its effectiveness has been limited as borne out by the findings of the other thematic areas on ecosystems, land-based pollution and fisheries and this is occurring in the midst of heightened exposure to the impacts of climate and natural hazards. The assessment reveals medium risks in policy completeness, with very low risks in integration and engagement while key governance challenges include weak enforcement, competing commitments for coastal and marine conservation reliance on external funding for sustainability, and socio-economic pressures driving destructive practices. This makes imperative the urgent need for strengthened and consistent implementation, enhanced inter-agency coordination, community empowerment, and sustainable financing that could be integrated into a coherent strategic action programme anchored on regional cooperation taking into account current international biodiversity and climate targets and the SDGs.

Keywords: Administrative arrangements, transboundary governance, enhanced inter-agency coordination, strengthened and consistent implementation



6. Governance

There was some degree of optimism back in the year 2000 when the first transboundary diagnostic analysis (NTDA 1.0) for the Philippines was prepared and there was an anticipated paradigm shift in views towards improved environmental management in general and in integrated coastal zone management (ICZM) arena. This was eventually carried out by a flurry of movement policy-wise on matters relating to coastal and marine resources management including land-based pollution which proceeded to the establishment of comprehensive measures on clean water, clean air, protected areas, fisheries and later integrated coastal management.

The true test of effective governance lies in whether all the institutional mechanisms and practices that were developed delivered on their supposed objectives and policy declarations. From the various thematic areas in previous chapters, it appears the supposed outcomes on healthy ecosystems and fishery resources have not really occurred, and they face the prospect of being further degraded, even diminished further with the intensifying threat of climate and natural hazards. What is important then is to have a further examination of what might be needed, even at the level of regional cooperation and the application of useful international frameworks, so that the supposed meaningful vision of a healthy and vital coastal and marine ecosystem will still be realized, if all the institutional players in the entire governance infrastructure do their part and just continue to work on the things that need to be done, without further short-cuts or exemptions or let-up, then the continued degradation of coastal and marine ecosystems including land-based pollution that have been well-documented in other thematic areas might as well pause and instead proceed into steady and continued recovery.

6.1 Key Findings

This report on Governance tracks the key recommendations on legislation and policies from the 2000 Transboundary Diagnostic Analysis (UNEP, 2000) and updates them for this 2025 assessment:

- On pollution in water-related issues, NTDA 1.0 for the Philippines recommended to establish legal and institutional mechanisms for environmental monitoring and compliance systems with public and private sector participation, implementation of programmatic environmental impact assessments for pollution abatement and use of market and non-market based interventions. These are now addressed by the **Clean Water Act** in 2004 although in 2025 the NTDA 2.0 recommends for the strengthened implementation of said law in terms of enforcement and funding.
- On the improvement of water quality, NTDA 1.0 for the Philippines recommended for the strengthening of legal and institutional support for integrated watershed management systems, for enhanced management of the surface and groundwater resources and the prioritization of water conservation and the regeneration of degraded water reservoirs and improving the water resources development boards at the local, regional and national levels. These recommendations were largely not acted upon but are now presented in a comprehensive proposal for a **Department of Water Resources** for consideration and implementation.
- On the over-exploitation of the living aquatic resources and promoting its sustainable utilization, proposals included the institutionalization of inter-agency action programmes on aquatic and marine resources conservation and management while stimulating public and private sector cooperation through national and regional fisheries management councils and harmonizing social and economic incentives. These are now established through the **Fisheries Code**, and the **Wildlife Act** to protect dugong and marine turtles under the DENR's Biodiversity Management Bureau which was reinforced by legislation established for protected areas through **the National Integrated Protected Areas Act** passed in 1992 but expanded in 2018 through the **Expanded National Integrated Protected Areas Act**.
- On the matter of land care and integrated coastal management, the DENR was recommended to be the lead agency to integrate land care, i.e., agriculture and watershed management and integrated coastal management

and to enact appropriate land use and coastal zonation plans for all municipalities. This is now carried out through **Executive Order 533**.

Further, the various thematic areas of the 2025 TDA showed some key governance findings:

The **SOCIO-ECONOMICS** thematic area (Agaton and Ancheta, 2025) underscored the need for **well-trained** people who will explore smart solutions supported by **well-capacitated stakeholders** including the necessity of having **clear guidelines** that will strengthen legislative-executive support for sustainable efforts as to how different sectors should contribute to reaching the required indicators for sustainable development and in all of these to increase **network-building and partnerships** such that all relevant communities could be involved.

The **LAND-BASED POLLUTION** thematic area (Promentilla and Aguila, 2025) noted that **significant gaps** remain in the implementation, enforcement and monitoring of infrastructure development while also noting **institutional fragmentation of implementation** by identified agencies in the Clean Water Act of their mandated roles, **limited funding** for infrastructure, and **inconsistent enforcement** of discharge standards continue to hamper effective domestic wastewater management. In addressing wastewater from industrial effluents, the lead agency that will address this, the DENR **still lacks a central database** that aggregates effluent volumes, and pollutant loads from all regulated facilities to estimate the pollutant load reliably.

The **ECOSYSTEMS (Coastal Wetlands)** (Galon, 2025) thematic area identified the need for a **comprehensive approach** to protect the remaining mangrove and wetland resources of the country, including **stronger community involvement and empowerment**. The **strict enforcement of the existing laws** is still one of the critical activities needed to save the remaining environmental resources of the Malampaya Sound and the coastal western seaboard of the Philippines. In addition, regular monitoring of environmental resources and water quality is needed.

The **ECOSYSTEMS (Coral Reefs and Seagrasses)** (Felix, 2025) thematic area identified the need to strengthen legal and institutional frameworks for ecosystem-based management including the laws and institutions that guide how the coasts and oceans are managed. Connectivity across ecological corridors is also recommended, as well as standardizing monitoring protocols for corals and key wildlife across the Philippine Seas in the SCS-LME and SCS region. The local communities also need to be engaged in enforcement and stewardship with their role in monitoring fishing pressure, promoting compliance, and supporting evidence-based management decisions at the local level considered necessary for effective implementation.

6.2 Current Status

6.2.1 Economic and Policy Drivers

6.2.1.1 Political and Economic Drivers

According to the *World Bank 360 database* (World Bank, n.d.), the **annual GDP growth** of the Philippines from the year 2000 to the latest year 2023 with available data, shows an unsteady up-and-down pattern but over-all it fares comparatively well vis-à-vis the global trend as seen in Figure 6.1.

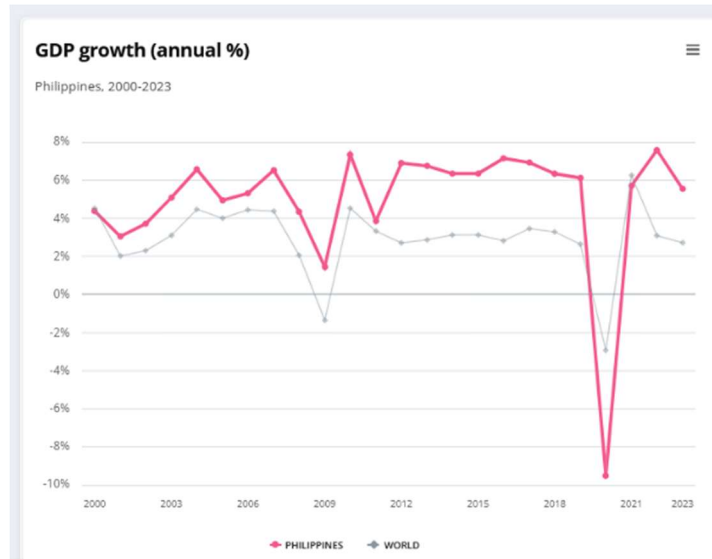


Figure 6.1 Philippine GDP growth, 2000-2023 (World Bank 360 database)

Notwithstanding that up-and-down trend above, within the same 20-year period, the Philippine **GDP per capita** has shown a steady upward trend, from the year 2000 to 2020 as seen in Figure 6.2 below:

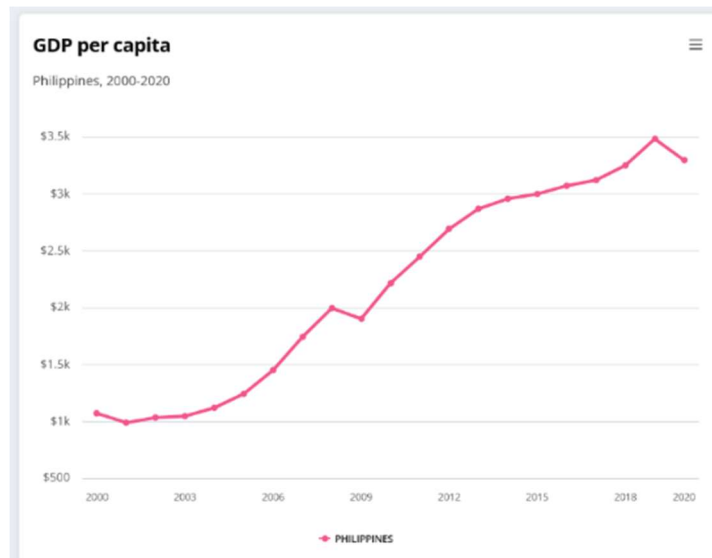


Figure 6.2 Philippine GDP per capita (World Bank 360 database)

This upward trajectory can also be seen in **government revenue**, as seen in **Figure 6.3**.

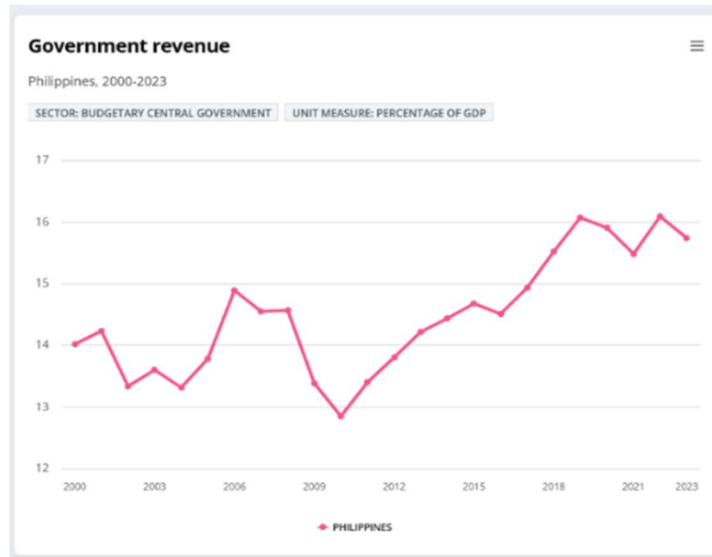


Figure 6.3. Philippine government revenue, 2000-2023 (World Bank 360 database)

6.2.1.2 National Budgetary Allocations for Coastal and Marine Resources Management

The budgetary allocations for coastal and marine management-related activities within a 10-year period (2016-2025), of key agencies tasked for these concerns, the Bureau of Fisheries and Aquatic Resources (BFAR) as well as the coastal and marine management program of the Department of Environment and Natural Resources (DENR), show stable funding, as can be seen in the Annex 6.A, Table 6.A.1 and in Figure 6.4 below. Whether these resources are adequate is something that cannot be fully determined at this time considering the many factors that need to be considered, i.e., incomplete assessment of actual need the stated priorities of the agencies and the actual challenges and difficulties in implementation that will affect the actual amount that will be needed to implement identified plans, programs and activities.

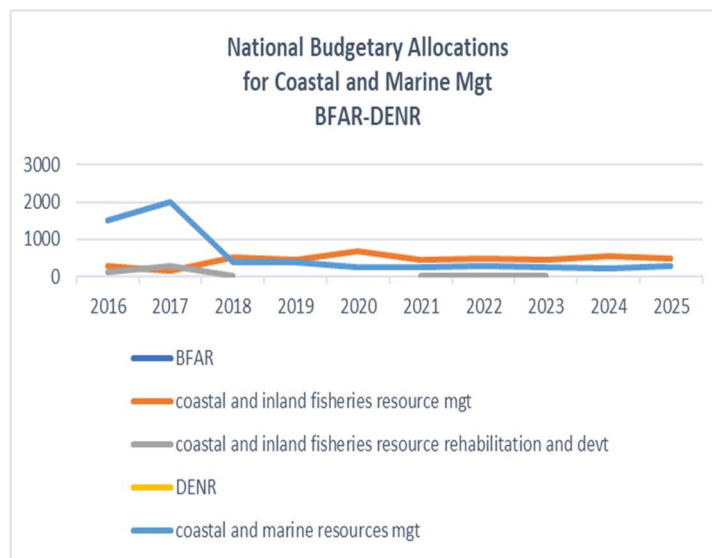


Figure 6.4. Coastal and Marine Resources Management Budgetary Allocations (General Appropriations Act 2016-2025)

6.2.2 Institutional Setting

6.2.2.1 Institutions, Regulatory Agencies, and Administrative Arrangements

The Department of Environment and Natural Resources is mandated under **Executive Order 533** issued by the Philippine President in 2006 (Official Gazette, n.d.), to lead all concerned national agencies in the implementation of the integrated coastal management (ICM) programme and promote best practices that fall within their respective mandates. The support agencies shall identify, prepare, and provide policy guidance, and technical and resource assistance to DENR and local government units (LGUs) in the implementation of the National and Local ICM Programmes and enforcement of relevant coastal and marine policies and regulations.

On the other hand, the LGUs or sub-national governments, shall act as the frontline agencies in the formulation, planning and implementation of ICM programmes that shall be in line with the National ICM Programme (*Ibid.*).

The Fisheries Code passed by the Philippine Congress in 1998 has provided for **Fisheries and Aquatic Resources Management Councils (FARMCs)** to be established at the national level and in all municipalities/cities abutting municipal waters. The FARMCs shall be formed by fisherfolk organizations/cooperatives and NGOs in the locality and be assisted by the LGUs and other government entities (DA-BFAR, n.d.). The FARMCs are also organized up to the barangay level.

The LGUs, as provided by the **Local Government Code** (DILG, n.d.), possess a wide degree of latitude in enacting ordinances on coastal resources management using the **general welfare clause**, which authorizes the local government units to enact ordinances for the good of the municipality and its inhabitants (Supreme Court of the Philippines, 2004).

The BFAR has recently issued an administrative order setting up **Fisheries Management Areas (FMAs)** (DA-BFAR, 2021) to manage the straddling and shared fish stocks within the FMAs, taking into account the ecosystem approach to fisheries management (EAFM) (*Ibid.*). A **management body** shall be created for each FMA which shall be the operating entity that will manage the affairs of an FMA (*Ibid.*).

This management body in the FMAs is envisioned to function similarly like **the protected area management boards or PAMBs**, a multi-sectoral body created in each protected area which may either be in the terrestrial or marine environment, vested with powers of budget allocations, approval of proposals for funding and matters relating to planning, peripheral protection and general administration of the protected area in accordance with the general management strategy, among others. (DENR, 2002).

The country's efforts on implementing the SDGs and particularly in SDG 6.5.1 on Integrated Water Resources Management is in **Annex 6.H: Supplementary Material A**.

6.2.2.2 Informal Arrangements and Structures

These informal arrangements and structures are understood to be the ways which enable communities to manage their coastal and marine resources using their indigenous and customary ways of doing things which may or may not be documented and are often associated with how their local ecological knowledge or indigenous knowledge systems.

In the island of Coron, one of the project sites in Palawan, the indigenous cultural community, the **Tagbanuas**, who are engaged in traditional fishing practices within their ancestral waters in the context of sacred marine areas or *panya'an* which is similar to fish sanctuaries. They are also dependent on fishing, hunting and foraging

(Capistrano, 2010). The Calamian Tagbanua homeland was once host to rich, diverse, unique and ecologically intact marine and terrestrial ecosystems but the onslaught of dynamite and cyanide fishing have now reduced their coral systems to rubble (De Vera and Zingapan, 2007). Then in the early 1970s, the municipal government of Coron seized all the clan caves in Coron Island and auctioned them off (subasta) to raise revenue for the municipal treasury, and the Tagbanuas of Coron Island were reduced from being owners and sellers to gatherers paid for their labor. The Tagbanuas slipped into further misery, when the municipal government auctioned off tax declarations which had lapsed with their payments to tourist resort developers, real estate agents, and the like (*Ibid.*).

The Tagbanuas organized and filed an application for a **Certificate of Ancestral Domain Claim or CADC** with the DENR which was approved in 1998 by then DENR Secretary Victor O. Ramos, consisting of 22,400 hectares of land and waters. In 2002, the National Commission on Indigenous Peoples (NCIP) converted the Tagbanwa's CADC into a **Certificate of Ancestral Domain Title (CADT)**, and after the review and revalidation increased it to 2,236 hectares (De Vera and Zingapan, 2007). This Coron CADT was a precedent for further recognition of two other CADT claims in Northern Palawan (*Ibid.*).

6.2.3 Legal and Policy Setting

6.2.3.1 International Legal/Policy Frameworks & Forums

Table 6.1 below shows the various international legal/policy arenas and forums to which the Philippines is a Party or has joined on the date indicated.

Table 6.1 Philippine's Engagement with International Legal/Policy Arenas

Policy Arena/Forum	Date of PH Ratification/Accession
United Nations Convention on the Law of the Sea (UNCLOS)	Signature – 10 December 1982; entry into force -16 Nov 1994
UNCLOS Implementing Legislations	Approved: March 10, 2009
- Philippine Baselines Act (Republic Act 9522)	Approved: November 7, 2024
- Philippine Maritime Zones Act (Republic Act 12064)	Approved: November 7, 2024
- Philippine Archipelagic Sea Lanes Act (Republic Act 12065)	
Fisheries-related instruments	
Agreement relating to the implementation of Part XI of the UNCLOS Convention of 10 December 1982	Acceded: 23 July 1997
UN Fish Stocks Agreement	Acceded: 24 September 2014
FAO Compliance Agreement	Acceded: 30 May 2018
2009 FAO Agreement on Port State Measures	Acceded: 26 April 2018
WTO Agreement on Fisheries Subsidies	Acceptance: 24 February 2024
Biodiversity-related instruments	
Convention on Biological Diversity (CBD)	Ratified: 8 October 1993
Convention on Migratory Species (CMS)	Ratified: 1 February 1994
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Ratified: 18 August 1981
International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)	Acceded: 27 December 2006
Ramsar Convention on Wetlands, World Heritage Convention	Acceded: 8 November 1994
International Plant Protection Convention	Ratified: 19 September 1985
International Whaling Commission	Ratified: 3 December 1983

Member from 1981-1988

Maritime Pollution-related instruments

International Maritime Organization (IMO) Convention
International Convention for the Prevention of Pollution from Ships
(MARPOL) and Annexes I-VI

Year joined: 1964

Climate Change-related instruments

United Nations Framework Convention on Climate Change (UNFCCC)
Kyoto Protocol
Paris Agreement

Ratified: 2 August 1994
Ratified: 20 November 2003
Ratified: 23 March 2017

Sustainable Development Goals

2030 Agenda for Sustainable Development
(UN General Assembly Resolution A/RES/70/1)

Adopted: 25 September 2015
PH joined all UN Member States in
unanimously adopting the 2030 Agenda for
Sustainable Development

6.2.3.2. Regional Legal/Policy Frameworks and Forums

At the ASEAN level, there is an **ASEAN Working Group on the Coastal and Marine Environment (AWGCME)**, that works on coastal and marine environment in coordination with the ASEAN Centre for Biodiversity (ACB) and the ASEAN Working Group on Nature Conservation and Biodiversity (AWGNCB), as well as other working groups and sectoral bodies. The AWGCME will oversee the planning, technical and implementation issues under this Strategic Priority Area, while the ASEAN Environment Ministers and the ASEAN Senior Officials on Environment will provide policy and strategic guidance for its work (ASEAN Secretariat, n.d.).

Another major ASEAN initiative of relevance to this review is the **ASEAN Leaders' Declaration on the Blue Economy** (ASEAN Secretariat, 2021), issued in the middle of the pandemic, in 2021. This was further elaborated in 2023 during the Chairmanship of Indonesia, where the **ASEAN Blue Economy Framework** (ASEAN Secretariat, 2023) was formulated, and there, the **ASEAN Blue Economy Vision** was articulated.

Transboundary Arrangements

The Philippines is also active in **PEMSEA**, **COBSEA** and the **Coral Triangle Initiative**, in addition to this current Project, the SCS-SAP, to pursue its constant efforts to ensure the effective conservation of this coastal and marine resources.

6.2.3.3 National and Subnational Legislation and Policies

At the outset, a key document in relation to coastal ecosystems management is the **1987 Philippine Constitution**, which declares that “the State shall protect the nation’s marine wealth in its archipelagic waters, territorial sea, and exclusive economic zone, and reserve its use and enjoyment exclusively to Filipino citizens” (Official Gazette, n.d.). This is further qualified by a mandate to Congress to pass a law which may “allow small-scale utilization of natural resources by Filipino citizens, as well as cooperative fish farming, with priority to subsistence fishermen and fishworkers in rivers, lakes, bays, and lagoons” (*Ibid.*).

The following **Table 6.2** lays out the key national laws and measures addressing coastal and marine resources management, including those that address fisheries and biodiversity conservation:

Table 6.2 Legislative and Policy Measures on Coastal and Marine Conservation and Management

Legislation/Policy Measure	Subject
Fisheries Code (Republic Act 8550) 1998	-Fisheries conservation and management
Fisheries Code amendment (Republic Act 10654) 2015	-Address and deter IUU fishing
Executive Order No. 533 (2006)	-Established ICM as a national policy framework
National Integrated Protected Areas NIPAS Act (Republic Act 7586) 1992	-Established the process for setting up protected areas, including marine protected areas
And its amendment, RA 11038 in 2018	

As to the establishment of marine protected areas, they are included in the **National Integrated Protected Areas Act** (Supreme Court E-library, n.d.), amended by the **Expanded National Integrated Protected Areas Act**, approved in 2018 (Senate, n.d.). The **Wildlife Act** (Official Gazette, n.d.) approved in 2001, mandated that jurisdiction over all terrestrial plant and animal species, all turtles and tortoises and wetland species, including but not limited to crocodiles, waterbirds and all amphibians and dugong is vested with the (DENR), while the Department of Agriculture (DA) shall have jurisdiction over all declared aquatic critical habitats, all aquatic resources including but not limited to all fishes, aquatic plants, invertebrates and all marine mammals, except dugong, and in the Province of Palawan, jurisdiction over all these species vested to the Palawan Council for Sustainable Development pursuant to Republic Act No. 7611 or the **Strategic Environmental Plan (SEP) for Palawan Act** (PCSD, n.d.).

In the most recent iteration of the **Philippine Biodiversity Strategy and Action Plan (PBSAP) 2024-2040**, there is a plan to expand the country’s marine protected areas from a baseline of 3.2 million has to 35.24 million has by 2040, as shown in **Figure 6.5**, from the most recent consultation activity by the Biodiversity Management Bureau in Iloilo City in September 16-17, 2025 (DENR-BMB, 2025):

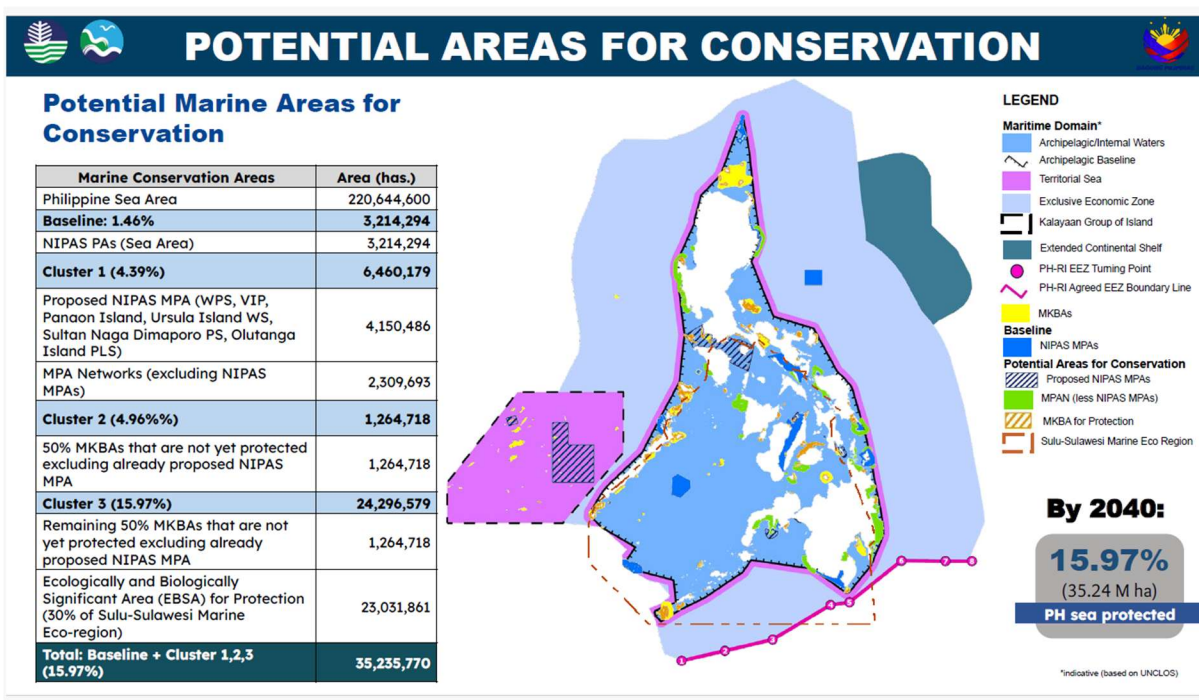


Figure 6.5. Potential Marine Areas for Conservation (DENR-BMB, 2025)

This PBSAP has also identified actions to be undertaken by key government agencies to implement the **Kunming-Montreal Global Biodiversity Framework** (CBD Secretariat, n.d.) which has an extensive set of targets to effectively manage these protected areas, including on marine spatial planning.

While the BFAR issued the **Fisheries Administrative Order No. 263, series of 2019** (DA-BFAR, 2023), which established **FMA**s to realize the ecosystem-based approach to fisheries management and integrated coastal area management. The Philippine Coast Guard, by virtue of its mandate under **Republic Act 9993**, the **Philippine Coast Guard Law of 2009**, is tasked in the enforcement of laws for the protection of marine environment and resources from offshore sources or pollution within the maritime jurisdiction of the Philippines (Senate, n.d.).

In regards to land-based sources of pollution, there is the **Executive Order No. 192**, which empowers the Environmental Management Bureau (EMB) of the DENR to: (a) Recommend possible legislations, policies and programs for environmental management and pollution control; (b) Formulate environmental quality standards such as the quality standards for water, air, land, noise and radiations; (c) Recommend rules and regulations for environmental impact assessments and provide technical assistance for their implementation and monitoring; (d) Formulate rules and regulation for the proper disposition of solid wastes, toxic and hazardous substances (Official Gazette, n.d.)

The EMB takes charge of overseeing the implementation of the **Clean Water Act**, which addresses water quality management in all water bodies, primarily applying to the abatement and control of pollution from land based sources (Senate E-Library, n.d.) . There is also the recently passed **Extended Producer Responsibility Act of 2022** that requires producers to be environmentally responsible throughout the life cycle of a product, especially its post-consumer or end-of-life stage (Senate of the Philippines, n.d.).

The land-based pollution thematic area report (Promentilla & Aguila, 2025) noted some persistent challenges in the following areas:

- a) Wastewater treatment due to rapid urbanization along coastlines and unabated infrastructure development;
- b) Pesticide and nutrient overloading in the country's river systems persist due to continuing agricultural intensification;
- c) Plastic pollution, along with solid waste, continue to pollute the country's waterways

All these are exacerbated by climate change, which is altering precipitation patterns, raising sea levels, and increasing the frequency of extreme weather events—all factors that influence pollutant transport and impact.

The Senate Economic Planning Office in 2023 proposed a suite of legislative measures to comprehensively address these problems, a key measure of which called for the creation of a **Department of Water Resources** (SEPO, 2023). A step towards this institutionalization is the establishment of the **Water Resources Management Office** (Official Gazette, n.d.) to be headed by an Undersecretary to be appointed by the President, upon the recommendation of the DENR Secretary.

Recently, in regard to the implementation of the ASEAN's *Blue Economy Framework* recently (Aksyon Klima, 2025), the DENR laid out its key priorities for the next two years 2025-2026, and among the measures that are being eyed that relates to the blue economy include a **draft policy on blue carbon** to complement the Blue Economy Bill and other initiatives under the National Blue Carbon Action Partnership (NBCAP) and the creation of a **blue economy database** that would track the involvement of stakeholders and ongoing initiatives related to the promotion of a blue economy. The DENR also launched the **NBCAP** between the Zoological Society of London, UK DFID and DENR-BMB was launched in UNFCCC COP 28 in 2023 (DENR, 2023).

There are pending legislative measures on the Blue Economy and these measures will have to be passed to fully articulate the **Philippine Oceans Policy**, of which there was one referred to by the Philippine delegation in the recent UN Oceans Conference in Busan, South Korea (Department of Foreign Affairs, 2025).

6.2.4 Civil Society, Stakeholders and Participation

6.2.4.1 Key NGOs and Special Interest Groups

The key non-government organizations (NGOs) working on coastal and marine issues in the Philippines includes the **NGOs for Fisheries Reform (NFR)**, composed of 12 non-government organizations which has been in existence since 1994. There is also the **PAMALAKAYA-Pilipinas**, a militant alliance of small fisherfolk established in 1987, with 9 regional chapters, 43 provincial chapters and over 80,000 individual members nationwide (PAMALAKAYA, n.d.). These NGOs are effective within their areas of advocacy, though in essence, not all of their concerns are immediately integrated in government policies, programs and activities as they will have to be further reviewed before they are taken on-board.

There are also area-based NGOs such as the **Marine Conservation Philippines (MCP)** based in Zamboangita, Negros Oriental that uses science to understand how local and global pressures affect marine ecosystems, and they empower, engage, and build local and national capacity to reduce and adapt to these pressures, aiming for a sustainable future for the Philippine people and environment (MCP, n.d.) or the **Coral Reef & Rainforest Conservation Project** which implements several marine conservation projects in Siquijor Island (CRCP, n.d.). These NGOs follow the path taken by **Coastal Conservation and Education Foundation, Inc.**, which, since 1998, helped conserve coastal and marine resources for the benefit of all coastal residents in various coastal communities in the Visayas (White, 2024).

6.2.4.2. Trade Associations and Business Groups

When Batangas Bay was identified as a national ICM demonstration site in 1994, it provided a more focused direction to the **Batangas Coastal Resources Management Foundation (BCRMF)**, earlier established in 1991. The Foundation, organized through the efforts of the provincial governor and five of the largest companies in the province: Pilipinas Shell, Caltex Philippines, Chemphil Albright Philippines, AG&P Inc., and General Milling Corporation, provided supporting funds, staff, and other logistical support for the implementation of the ICM program, covering such activities as public awareness, coastal cleanups, coral reef rehabilitation, and monitoring of environmental changes in Batangas Bay (PEMSEA, 2023).

6.2.5 Governance Performance and Effectiveness

Good governance is about adhering to principles of participation, transparency, accountability, equity, and coordination. At the national level, an assessment of existing governance arrangements and processes was undertaken to identify whether they are consistent with accepted institutional norms and practices (i.e., architecture, process, engagement):

- **Governance architecture** – there are institutional arrangements in place, established formally by law, particularly the **Water Quality Management Area (WQMA) Governing Board** for clean water, as well as the **Airshed Governing Board** for air pollution. For coastal and marine resources management, there's the **FARMC framework** which starts at the national level and at various levels which is now updated into FMA

which should act like a protected area management board (PAMB) that is the main mechanism established for biodiversity conservation and management at the local level.

These structures can also be replicated at the local government level whenever there's political acceptance for it, thus a similar local-level WQMA Governing Board, or a PAMB may also be recreated. This is possible because of the inherent power accorded to the local government unit to establish similar governance structures.

The problem arises when these established local government structures that are similar to the national-level institutional arrangements make decisions that do not take into account the national-level bodies' decisions or guiding parameters for effective conservation and management efforts either due to lack of capacity, funding or political will. This is not limited to an issue of communication but of effectively considering each other's initiatives that will need to be considered when local decisions are to be made. Truly, Mahon and Fanning's point on what "coordination" means, which involves communication and some mutual adjustment of activities among multiple existing decision-making centers as well as "integration", which means a deliberate process to combine or link diverse, often fragmented, sectoral plans and policies into a single, cohesive, holistic framework for comprehensive management, is illustrated starkly in the case of the Philippines where the proliferation of local parallel governance structures are not coordinated or integrated with the nationally-established governance structures.

This propensity of institutional structures to be also replicated down to the local government level but not having the capacity and the means to address the concerns of coastal and marine resources management and land-based pollution at their level also leads to a fragmentation of implementation efforts that are apparent in how certain issues like land-based pollution, are addressed, but actually failing to achieve the desired outcomes

- **Coverage of the full set of issues** – the legislation setting up these governance entities have identified the responsibilities for the full range of issues, including at the local level. While it is feasible that the locally-organized governance structures may also deal with the full set of these concerns, the issue arises whether they have the requisite capacity to fully implement the identified measures to address coastal and marine resources management and pollution concerns. In addition, the full set of resources, technical and administrative, to fully administer these policy measures needs to be in place.
- **Coverage of the full policy cycle (data and information, formulation and provision of advice; decision-making; implementation; and review and evaluation of policy and implementation)** - the full policy cycle is largely covered by all governance structures reviewed but what is missing is the continued effort to review and evaluating these policies' effectiveness including their implementation, These governance structures and mechanisms do not have an effective mechanism for fully reviewing and evaluating its past policies and their implementation, thus there is a need to fully regularize the impact evaluation of the policies that are identified and reviewed here.

Some details of this assessment can be found in **Annex 6.F.2**

Effective governance is about achieving results, often measured by indicators like government effectiveness and regulatory quality (World Bank Governance Indicators). Effective governance is a *component* or *result* of good governance, as adherence to good governance principles often leads to more effective and sustainable outcomes.

An assessment was undertaken to determine whether governance practices have achieved what they were established to do (ecosystem pressure, ecosystem state, social justice, human well-being), and resulted in changes in

peoples' behavior and changes in ecosystem states. An elaboration of this can be found in an **Supplementary Material 6.B** while the corresponding Gap Analysis is in **Annex 6.H: Supplementary Material C**.

6.3 Discussion and Conclusions

6.3.1 Risk Assessment: Current Governance Capacity to Engage Stakeholders, Reduce Ecosystem Stresses, Improve or Protect Ecosystems, Achieve Socially Just Outcomes, and Improve Human Well-Being

At the national level, the Philippine's national-level performance can be observed through broad global governance indicators:

- **Environmental Performance Index (2024):** The Philippines was ranked 168th out of 180 countries, with a low overall score, indicating significant environmental challenges, particularly in waste management. This suggests systemic issues that could filter down to provincial-level implementation.
- **Government Effectiveness Percentile Rank:** Captures the quality of public services, the capacity of the civil service, and the quality of policy formulation and implementation. The Philippines generally remains in the medium tier for government effectiveness, which suggests some strengths in its governance, but also indicates an opportunity to improve compared to other countries globally the quality of civil service and policy implementation. This would likely impact the capacity at provincial levels
- **Regulatory Quality Percentile Rank:** Assesses the ability of a government to formulate and implement sound policies and regulations that permit and promote private sector development. Whilst ranking in the medium tier globally, the Philippines has a generally steady ranking in its regulatory quality percentile rank over time, indicating some challenges in its national regulatory environment. Effective national regulatory quality is crucial for developing and enforcing rules that can be implemented at the provincial level, including for fisheries management and pollution
- **Control of Corruption Rank:** is ranked in the lower tiers, and has shown to have decreased Philippines in the last two decades

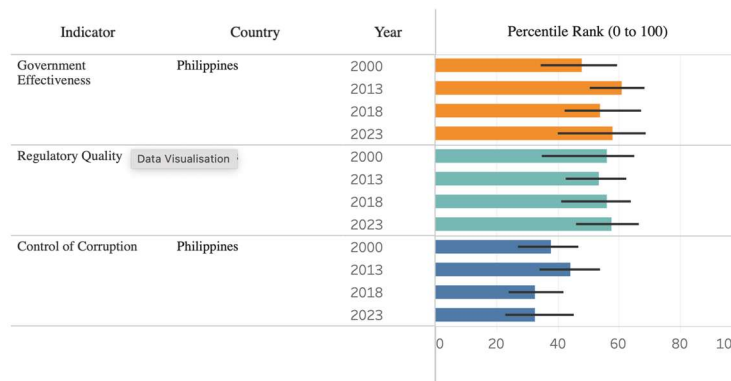


Figure 6.6. Indicators for Governance (World Governance indicators <http://www.govindicators.org/>)

While specific data on provincial capacity for the Philippines is not available, the assessment using the national-level governance indicators suggests that the Philippines faces challenges in its governance capacity at the provincial level within the South China Sea.

At the provincial level, the governance review undertook a consultative risk assessment of governance capacity using the Governance Architecture Risk Ranking Guide from the TWAP Assessment of LME's (Fanning *et al.* 2017) to assess completeness, integration and engagement, particularly at the project site level.

The assessment drew from information collected through a questionnaire provided at the NTDA Inception Workshop in March 2025 (see **Annex 6.A**) to key stakeholders from the project sites, with the results of this assessment as follows: medium risk of completeness, and very low risk for integration and engagement. In comparison, the TWAP Assessment of Governance Architecture for the transboundary governance of the South China Sea of: medium risk of completeness, high risk for integration, and low risk for engagement.

The detailed results of this assessment based on the responses to the questionnaire is in **Appendix 6.A.1**:

Table 6.3. Governance Architecture Risk Ranking Guide (Fanning et al., 2017)

Risk Rank	Completeness Range	Integration Range	Engagement Range
Very Low	80-100%	0.8-1.0	80-100%
Low	60-80%	0.6-0.8	60-80%
Medium	40-60%	0.4-0.6	40-60%
High	20-40%	0.2-0.4	20-40%
Very High	0-20%	0.0-0.2	0-20%

RESPONDENTS	COMPLETENESS (6/11)	INTEGRATION (10/11)	ENGAGEMENT (11/11)
stakeholders from the project sites	54.5%	90.9%	100%
Risk Rank	Medium	Very Low	Very Low

6.3.2 Current Governance Capacity to Respond to Climate and Major Environmental Changes, as well as Population Growth and Demand

There currently exists the **Climate Change Commission**, established by the **Climate Change Act** (Climate Change Commission, n.d.), which provides some capacity governance-wise, in addressing climate change and other environmental issues. The challenge lies in getting these initiatives mainstreamed in government-wide efforts considering that the Philippine President, the supposed Chair of the Climate Change Commission, has largely delegated the running of the Commission to his designated Cabinet Secretary.

The recent **State of the Climate in the South-West Pacific 2024 Report** showed some good news citing a case study pointing to strengthened early warning systems and Anticipatory Action in the Philippines that enabled communities to prepare and respond to the back-to-back typhoons in 2024. This helped to protect lives and livelihoods and ensure dignified, timely support for vulnerable communities (WMO, 2025).

6.3.3 Strategies to Enhance Government Responses to Climate Change and Achieve Sustainability of the Coastal and Marine Environments

The **Philippine Development Plan 2023-2028** (NEDA, 2023), which is currently being updated to accord by the current administration, lays out the government’s broad-based strategy to enhance government responses to climate change and the sustainability of the coastal and marine environments. Climate change is addressed in Chapter 15 of the said Plan which seeks to accelerate climate action and strengthen the country’s disaster resilience. The promotion of the country’s coastal and marine environment is couched in terms of securing the country’s food security in Chapter 5 of the same Plan which seeks to modernize the country’s agriculture sector while emphasizing and allocating the needed resources to harness the full potential of the blue economy.

6.3.4 Recommended Priority Actions Including Regional Cooperation

Given the existence of institutional frameworks and mechanisms that address the issues identified back in the NTDA 1.0, a major effort needs to be made to make sure that the current policy and governance infrastructure and mechanisms work and deliver effective and good outcomes, starting from making sure they are funded more than

sufficiently and the institutional entities that are tasked with implementation possess the appropriate capacity with the appropriate political will to carry them out given existing and forthcoming challenges.

Equally as important is a steady and consistent effort at implementing these existing policy frameworks to ensure they achieve their identified policy targets and outcomes. The government agencies and stakeholders have faced challenges to the extent that the Supreme Court, which is not generally tasked with implementing laws and policies has played a supervisor role over the government agencies to make sure they carry out their mandate, roles and responsibilities under existing laws. This is what has happened in the case of Manila Bay, which, in essence is an atypical effort at implementing specific government policies on a particular spatial area and should not in any way be touted as a best practice at government agencies coordinating their efforts over a particular subject matter.

While priority actions and recommendations for regional action are also detailed in each of the thematic chapters this review and the academic literature has identified the following challenges on which to build these priority actions and areas for regional cooperation:

- **Decentralized Governance and Local Implementation:** The Philippines has adopted a decentralized approach where Local Government Units are crucial in implementing marine environmental policies, particularly for Marine Protected Areas. This involves establishing legal frameworks that integrate national and local contexts (Espanilla, 2020) and fostering co-management initiatives with fishing communities (Sunderlin & Gorospe, 1997).
- **Challenges in Data, Funding, and Enforcement:** A consistent finding is the significant challenge of **poor data collection and reporting** at all levels, from municipal to national, which directly impacts the effectiveness of policy and enforcement at the provincial level (Grantham et al., 2022). Many MPAs, often managed by local governments, face **budgetary constraints and lack sustainable financing** (Maypa et al., 2012). There are also persistent issues with **insufficient monitoring and documentation**, which hinder proper management (Viability of UNCLOS amid Emerging Global Maritime Challenges, 2024).
- **Institutional Capacity Gaps:** While decentralization aims to enhance local autonomy, its effectiveness can be impeded by "institutional capacity gaps, political interference, and limited financial autonomy at the local government level" (Moreno & Sulasula, 2024). Overall, a critical challenge is the "persistent lack of institutional coordination and insufficient human resource capacity, particularly at provincial levels," which undermines effective policy implementation [current document].
- **Localized Assessments and Progress:** Despite these systemic challenges, there are instances of successful localized governance. For example, some studies assess the effectiveness of local government initiatives in specific areas, such as MPA implementation in Sarangani Province (Jama & Flores, 2024) and the Visayan Region, where higher-rated MPAs correlate with better coral reef health (Maypa et al., 2012). The importance of harmonizing policies across different governance levels and engaging local communities has been highlighted as crucial for environmental improvement in case studies like Batangas Bay (Ishii, n.d.).

The National Validation Workshop held last 12-14 November 2025 also generated governance-related recommendations as can be seen in **Annex 6.G**.

6.4 Methodology and Analysis

This chapter did a textual analysis of legal and policy documents and compared them with available accomplishment reports of key agencies online. National and sub-national data was collected online for analysis within the Palawan and Batangas provinces (**Annex 6.B**).

Glossary

- **Certificate of Ancestral Domain Claim (CADC)**, also **Certificate of Ancestral Land Claim (CALC)** - refers to the land tenure instrument issued by the DENR recognizing the claim of indigenous cultural communities on land, resources and rights thereon within a defined territory.
- **Certificate of Ancestral Domain Title (CADT)** refers to a title formally recognizing the rights of possession and ownership of ICCs/IPs over their ancestral domains identified and delineated in accordance with R.A. No. 8371.
- **Coordination** involves communication and some mutual adjustment of activities among multiple existing decision-making centers. It often happens within sectors (e.g., within fisheries ministries) or at sub-regional levels. It is a necessary but often insufficient step for addressing complex, transboundary, ecosystem-based challenges
- **Fisheries and Aquatic Resources Management Councils (FARMCs)** – is an institutional mechanism established by the Fisheries Code formed by fisherfolk organizations/cooperatives and NGOs in the locality and assisted by the LGUs and other government entities. Before organizing FARMCs, the LGUs, NGOs, fisherfolk, and other concerned POs shall undergo consultation and orientation on the formation of FARMCs.
- **Fishery Management Areas or FMAs** are areas (bay, gulf, lake or others) identified by the Department of Agriculture’s Bureau of Fisheries and Aquatic Resources (DA-BFAR) as major fishing grounds based on stocks boundary/range/distribution, structure of fisheries and administrative subdivisions which integrate science-based, participatory and transparent governance framework and mechanism to sustainably manage fisheries in such areas to stop overfishing, fight illegal, unregulated and unreported fishing and promote food security and poverty alleviation in the Philippines.
- **Integrated Coastal Management or ICM** is a dynamic process of planning and management involving stakeholders, and requiring the analysis of the environmental and socioeconomic implications of development, the ecosystem processes, and the interrelationships among land-based and marine-related activities across jurisdictions
- **Integrated Coastal Zone Management or ICZM** is a resource management system which employs an integrative, holistic approach and an interactive planning process in addressing the complex management issues in the coastal area. It could serve as the blueprint for attaining the goals and objectives of sustainable development by maintaining the functional integrity of the coastal systems, reducing resource-use conflicts, maintaining the health of the environment and facilitating the progress of multisectoral development.
- **Integration** is a deliberate process to combine or link diverse, often fragmented, sectoral plans and policies into a single, cohesive, holistic framework for comprehensive management (such as Integrated Ocean Management or Ecosystem-Based Management). It requires creating specific institutional mechanisms to ensure consistency across policy goals, shared vision, and effective decision-making.
- **Local government units** are institutional units whose fiscal, legislative and executive authority extends over the smallest geographical areas distinguished for administrative and political purposes.

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Chapter 6 Annexes

Annex 6.A Results from Interview Questions

Results from Interview Questions Provided to Inception Workshop Participants

1. Are you aware of current policies and measures that deal with coastal and marine resources management in your area of work/operation/activity and if you are aware, can you enumerate what are they?
2. Are these policies and measures complete which means they address all the issues and concerns that need to be addressed and if your answer is no, please explain.
3. What are the gaps in the implementation of these policies and how do you think they need to be addressed?

Table 6.A.1. Assessment results (Current Policies and Measures and Completeness/Adequacy)

	Respondent Type	Current Policies and Measures	Completeness/Adequacy (6/11)
1	NGO1	Not aware	No.
2	NGO2	ICM code, solid waste management ordinance, anti-plastic ordinance, sewage management ordinance	At one point, it is complete. However, some issues arise that will merit a review of the policy.
3	NGO3	Mabini has an existing IRR and ICM	ADEQUATE
4	NGO4	ICM Code	Yes
5	LGU Coron	MPA ordinances, CLUP, Zoning Ordinance, ECAN Zones Map	Lack of MENRO as a focal person or responsible for environmental management in the LGU
6	PNP Maritime Unit	No dumping of garbage in waterways	While policies and measures exist for managing coastal habitats and land-based pollution, they are not necessarily complete or adequate due to challenges in enforcement funding, and the transboundary nature of pollution.
7	PNP	National laws (E-NIPAS) and local ordinance	No, there is a need to revise policies and measures
8	Academe	ICM Code	No
9	DENR PENRO Palawan	NIPAS (PAMP): local fishery code	Complete but needs harmonization and funding
10	DENR CENRO	eNIPAS Act, PAMP, Municipal Fishery Code, RA9003 Fishery Code of the Philippine (amended)	It is completed; however, the implementation of the policies should be intensive.
11	LGU Busuanga	“Establishment of the MPAs (5) Establishment of ECAN Coastal and Marine ECAN Map”	Policy Review and formulation of more comprehensive policies are still needed
12	PGENRO Palawan	Answers to follow	Answers to follow

Table 6.A.2. (Integration, Engagement, and Interventions to Address Gaps)

Respondent type	Integration (10/11)	Engagement (11/11)	Interventions to Address Gap
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1	NGO1	Not Aware	Maybe	Communication, Education and Public Awareness (CEPA)
2	NGO2	Yes, an inter-agency council supports this aim	Yes, consultations prior to the creation of the policy, involvement in monitoring and evaluation, feedback mechanisms	Self-policing mechanisms, group accreditation requirements, code of conduct
3	NGO3	Yes, through stakeholder consultations	LGU, Resort Owners, Fishing Folks, NGOs	LGU's implementation and support
4	NGO4	The ICM Code of Mabini is only being implemented in Mabini. As of my knowledge there are no current agencies using this	LGU, fisherfolk, dive professionals, boatmen, Resorts Owner Association of Mabini, PNP-MG, Coast Guard, Coast Guard Auxillary, MPIF, MEP-I	Lack of LGU support, and the capabilities of the <i>bantay-kalikasan</i> to enforce the code. But the biggest problem is corruption of the trust fund of the ICM office.
5	LGU Coron	There is resolution for the creation of the MENRO office. But there is still none appointed for the role.	Yes. The local community brings in to sectoral planning need for MENRO.	Appointment of MENRO in the LGU
6	PNP Maritime Unit	Yes, policies and measures should be designed to be integrated and mutually supportive across relevant agencies, ensuring they address the same issues cohesively and avoid duplication or conflict. This means policies and measures should be designed to be compatible and not contradictory, and should be communicated effectively to all relevant parties.	Private sectors and local units	To address policy and measure gaps, interventions should focus on strengthening evidence-based approaches, promoting interdisciplinary collaboration, and ensuring equitable access and implementation
7	PNP	Yes	LGUs SUC, local communities, national agencies and foreign stakeholder	Law enforcement gaps, inter-agency gaps and coordination gaps, there is a need to establish a robust law enforcement and coordination policies to effectively enforce relevant laws and ordinances
8	Academe	Yes	Yes, MPA management board. Dive professionals, resort owners, fisherfolk, freedivers, boat operators	Enforcement of rules inside MPAs. Implementation of existing policies and workplans.
9	DENR PENRO Palawan	Yes, but needs harmonization	Yes – MFI and WWF; conduct various CEPA and other behavioral change strategies in the local communities within PA	
10	DENR CENRO	Yes	Community-Based Forest Management PO of Brgy. Pansol and Brgy. Bato	Needs intervention on the implementation of policies and measures specially in the

			(Involved in the PAMP updating)	enforcement side of the implementing agency (ex. Organization of enforcement team of MSPLS together with the related agencies within the MPA)
11	LGU Busuanga	It should be. Some policies and prioritization still overlap with various agencies such as PCSD, DENR, BFAR, MAO, and MENRO	Women's Youth MFARMC IP Business Sector Tourism Sector NGO specialized on Environmental Management	<ol style="list-style-type: none"> All existing policies should be reviewed Align the policies to complement with international, national, and other relevant policies
12	PGENRO Palawan	Answers to follow	Answers to follow	Answers to follow

Table 6.A.3 Governance Architecture Risk Ranking Guide (Fanning et al. 2017)

Risk Rank	Completeness Range	Integration Range	Engagement Range
Very Low	80-100%	0.8-1.0	80-100%
Low	60-80%	0.6-0.8	60-80%
Medium	40-60%	0.4-0.6	40-60%
High	20-40%	0.2-0.4	20-40%
Very High	0-20%	0.0-0.2	0-20%

Respondents	Completeness (6/11)	Integration (10/11)	Engagement (11/11)
Stakeholders from the project sites	54.5%	90.9%	100%
Risk Rank	Medium	Very Low	Very Low

Annex 6.B SCS-SAP Project Sites

Table 6.B.1. List of SCS-SAP Project Sites

Province	Population	City/Municipality	Capital
Batangas	2,908, 484 (PSA, 2020)		
	50, 858 (PSA, 2020)	Mabini	Batangas City
	19, 215 (PSA, 2020)	Tingloy	
Palawan	939. 594 (PSA, 2020)		
	25, 617 (PSA,2020)	Busuanga	
	65. 855 (PSA, 2020)	Coron	Puerto Princesa City
	83,357 (PSA, 2020)	Malampaya Sound -Taytay	
	33, 507 (PSA, 2020)	-San Vicente	

Provincial Investment Profile

I. Batangas Province

Level of Economic Development

Batangas province contributes **21%** to the gross domestic product of the CALABARZON region, the second biggest economic region of the country next to the National Capital Region with a gross regional domestic product (GRDP) of **Php 571 billion pesos** (NEDA, 2023).

Economic Structure

According to the **Provincial Development and Physical Framework Plan 2022-2030** (Provincial Government of Batangas, 2022), the strategic location and positive economic climate in the Province of Batangas spurred the organization of economic activities in the province into the following three basic sectors:

- 1) Agriculture/Fishing and Forestry;
- 2) Industry Sector, which encompasses activities in mining and quarrying, manufacturing, construction and electricity, gas and water; and
- 3) Services Sector.

The SCS-SAP project sites, particularly the municipality of Tingloy, identifies the island municipality's role (Mabini, Bauan and San Pascual) as a rural settlement providing raw materials which is evident through the established market for fisheries products. This has implications on the exhaustion and the over exploitation of other fishery resources including the overworking of the fishermen (Reyes, Jr., 2018).

The municipality of Mabini, while known as a tourism hub, will soon become the site of an **Offshore Wind Integration Port (OSWIP)**, which will play a key role in the development of offshore wind farms in the Batangas/Mindoro region (Public Private Partnership Center, 2025). The impacts of this project is still to be determined pending the usual environmental impact assessment for this project.

II. Palawan Province

Level of Economic Development and Recent Updates in Economic Activities

Palawan Province, as of 2023, has a gross regional domestic product of **Php 129.10 billion**, with agriculture, fisheries and forestry contributing **25.2%** to its 2023 economic performance (PSA, 2023). On March 5 2025, the local legislative council at the provincial level, the Sangguniang Panlalawigan, **Provincial Ordinance No. 3646**, set a fifty-year extendable moratorium on the issuance of endorsements for all large- and small-scale mining applications, including applications for exploration permits, mineral agreements, and financial and technical assistance agreements in the province of Palawan (Office of the Sangguniang Panlalawigan of Palawan, 2025). This moratorium may result in reduced waterway pollution that will have a positive effect on the coastal and marine ecosystems in Palawan. However, a petition signed by various local and international NGOs dated 30 May 2025 (Rettet den Regenwald, e.V, 2025) showed that this ordinance has a loophole as the moratorium will not apply to the extensions or renewal of existing mining permits or agreements that do not involve new areas. Moreover, it will allow existing mining operations to continue, encroaching on indigenous peoples' territories, in various municipalities of Southern Palawan.

In the interest of promoting sustainable tourism in the province, the Provincial Government has recently proceeded with the commercial development of the 8.8 hectares of land located described as the **Coron Lagoons Waterfront Development Project** (Palawan Provincial Government, 2025).

The various investments mentioned here in the project sites, the **Offshore Wind Integration Port (OSWIP)** in Mabini, Batangas, and the **Coron Lagoons Waterfront Development Project** in Coron, Palawan, could have an outsized impact on the conservation efforts, including pollution prevention efforts that will be undertaken by the local government units in the sites.

Initiatives at the Project Sites

Since 1998 Kalikasan ng Pilipinas (KKP) has been carrying out conservation activities at Tingloy. It began with the establishment of the **Mabini-Tingloy Coastal Area Development Council**, a community-based, multi-sectoral, intermunicipal council (MATINGCADC) which it envisages as the one which ultimately manages the rich marine resources in the region. To ensure this further, the project reinforced the coastal law enforcer "BantayDagat" organized by the local council. "BantayDagat" patrols the municipal waters of Mabini and Tingloy every night until wide daylight to increase the level of safety and the area's protection from illegal fishermen. Recently, the municipality designated 22.01 hectares (54.4 acres) of thriving coral reef habitat as a marine protected area (MPA), only the second MPA to be established in the municipality which helped bolster an emerging ecotourism industry (Bacal and Garcia, 2024).

In the province of Palawan, as provided by Republic Act 7611, there is institutionalized the establishment of **Environmentally Critical Areas Network (ECAN)** that guides the plans, programs, and projects implemented by the local governments. Thus, in the municipality of Busuanga, they have an **Environmentally Critical Area Network (ECAN) Resource Management Plan 2017-2022** pursuant to this mandate (PCSD, n.d.).

Annex 6.C. Institutions and their Duties and Functions related to Governance

Table 6.C.1 List of institutions and their duties and functions related to Governance

Institution	Mandate	Linkages to Marine Governance	Legal Foundation
Department of Environment and Natural Resources (DENR)	The primary government agency responsible for:	Matters relating to conservation, management, development and proper use of coastal and marine resources	Sec. 4, Executive Order No. 192, series of 1987
	The conservation, management, development and proper use of the country's environment and natural resources, The licensing and regulation of all natural resources as may be provided for by law	Licensing and regulation of all activities related to the above	
	The primary government agency responsible for the implementation and enforcement of the Clean Water Act		Sec. 19, Clean Water Act, RA 9275
Environmental Management Bureau (EMB)	Matters relating to environmental management & pollution control	These mandates relate to the management and maintenance of the good quality of the marine ecosystem	Sec. 16 (a) and (b), Executive Order No. 192, series of 1987
	(c) Formulate environmental quality standards such as the quality standards for water, air, land, noise and radiations;		Sec. 16 (c), E0 192
	(e) formulate rules and regulation for the proper disposition of solid wastes, toxic and hazardous substances;		Sec. 16 (e), E0 192
	Converted to a line bureau to lead the implementation of the Clean Water Act		Sec. 34, Clean Air Act (RA 8749)
Biodiversity Management Bureau	(a) establishment and management of marine parks,	Setting up of marine parks and similar protected areas	Sec. 18 (a), EO 192
	(b) formulate policies for the preservation of biological diversity, genetic resources, and endangered Philippine flora and fauna;		Sec. 18 (b), EO 192
Bureau of Fisheries and Aquatic Resources (BFAR)	Formulate and implement a Comprehensive Fishery Research and Development Program, ... aimed at	These mandates relate to the utilization and belatedly, the conservation and	Sec. 65 (e), Fisheries Code, RA 8550

<p>increasing resource productivity, improving resource use efficiency, and ensuring the long-term sustainability of the country's fishery and aquatic resources;</p>	<p>management, of fisheries resources</p>	<p>Sec. 65 (g), Fisheries Code, RA 8550</p>
<p>Provide extensive development support services in all aspects of fisheries production, processing and marketing;</p>		
<p>Formulate and implement rules and regulations for the conservation and management of straddling fish stocks, highly migratory fish stocks and threatened living marine resources</p>		<p>Sec. 65 (r), Fisheries Code, as amended by RA 10654</p>

Annex 6.D. Legal and Institutional Mapping, and Stakeholders Related to Coastal and Marine Management

Table 6.D.1. Qualitative observation on Stakeholders' Coastal and Marine Management

Institution	Fisheries & Livelihoods	Ecosystem-based Assessment/ Marine Park Planning	Habitat	Pollution/ Nutrients	Endangered Species	Climate Change	Qualitative Observations
Department of Environment and Natural Resources (DENR)		X				X	
• Environmental Management Bureau (EMB)				X			There are clearly delineated areas of influence and competence of the various DENR bureaus
• Biodiversity Management Bureau (BMB)		X	X		X		There are clearly delineated areas of influence and competence of the various DENR bureaus
• Bureau of Fisheries and Aquatic Resources (BFAR)	X	X			X		Because of RA 10654, BFAR's mandate went beyond pursuit of fisheries and livelihood
Climate Change Commission						X	all aspects of coastal and marine management may also be addressed in the pursuit of climate change adaptation policies and measures
NGOs							These NGOs are advocacy organizations, they whenever they will secure funding for certain tasks, they will enter those areas of influence and advocacy
• NGOs for Fisheries Reform	X	X	X	X	X	X	
• PAMALAKAYA-Pilipinas							

Annex 6.E. Regulation Group Based on Issues

Table 6.E.1. Qualitative Observations on International Conventions, Regional Frameworks and Transboundary Agreements

No	International Conventions, Regional Agreements, Transboundary Agreements, Laws and Regulation, Plans and Action Plans	Biological Resources/ Ecosystems	Pollution	Fisheries	Climate Change	Qualitative Observations
International Conventions						
	UNCLOS					Sec. 56 now implemented through RA 12064
	UNCLOS Agreement on Part XI			x		
	UNCLOS Fish Stocks Agreement			x		
	FAO Compliance Agreement FAO Agreement on Port State Measures					
	Convention on Biological Diversity	x	x	x	x	Through the KMGBF, CBD lets states address a broader set of issues
	World Trade Organization			x		
	UNFCCC				x	
	Paris Agreement				x	
Regional Frameworks/Declarations						
	ASEAN Leaders' Declaration on the Blue Economy	x	x	x	x	
Transboundary Agreements						
	COBSEA			x	x	
	PEMSEA			x	x	
	CTI-CFF			x	x	
A	Laws and Regulations					
	Executive Order No. 533 on ICM	x	x	x	x	The EO addresses the inter-linkages among associated watersheds, estuaries and wetlands, and coastal seas, by all relevant national and local agencies.
	Clean Water Act		x			
	FAO 263, series of 2019	x		x		Institutionalizes the ecosystem approach to fisheries management (EAFM) that balance ecological well-being with human and societal well-being
B	Plans and Action Plans					
	PBSAP	x	x	x	x	The targets of KMGBF addresses all these concerns

Annex 6.F. Coastal and Marine Management Budgetary Allocations

Table 6.F.1. Coastal and Marine Budgetary Allocations for BFAR and DENR (GAA, 2016-2025)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BFAR										
Coastal and inland fisheries resource management plans	₱290.1 M	₱151.05 M	₱534.5 M	₱453.2 M	₱680.7 M	₱483.8 M	₱487.1 M	₱459.2 M	₱553.2M	₱477.8 M
Coastal and inland fisheries resource rehabilitation and development	₱112.7 M	₱304.05M	₱26 M (Oplan Sagip Ludong Project)			₱30 M (Operation alization of FMAs Program)	₱10M (FMAs Program)	₱11.132M (FishCORE Project)		
DENR										
Coastal and marine resources management	₱1.521 B	₱2.000B	₱400.3 M	₱ 388.5 M	₱243.8M	₱248.3 M	₱271.8 M	₱246.1 M	₱216.6	₱292.5M

Table 6.F.2. Good Governance Assessment

Category	Sub-category indicators	Evidence	Assessment
Governance Architecture	Existence and structure of institutions	What institutional arrangements are in place for governance?	WQMA Governing Board for clean water
	Agreements concluded		Airshed Governing Board for air pollution
	Mechanisms for linking stages of the policy cycle	Are they formal or informal?	Established by provisions of the law
	Mechanisms for integration		<ul style="list-style-type: none"> • Sec. 5 RA 9275 for WQMA Governing Board • Sec. 9, RA 8749 for the Airshed Governing Board
		Do they cover the full set of key issues, and do they make clear where responsibilities for implementation lie.?	The laws identified sets out action plans that address all key issues, including where responsibilities are, particularly the local government units, the private sector and other government agencies
		Is a policy cycle in place? five key stages: data and information, formulation and provision of advice; decision-making; implementation; and review and evaluation of policy and implementation	Yes, and while it appears evaluation of the policy has not been covered, there's a Joint Congressional Oversight Committee for the Clean Water Act (sec. 33) and for the Clean Air Act (sec. 53) to monitor the implementation of the law and review its IRR. It appears though

that the reports of these Committees are not available online.

Are there vertical and lateral linkages between levels; from local to global? E.g. NMC

The DENR provides data to NEDA (now DEPDev) for the latter's regular Voluntary National Reports for the achievement of the SDGs. Local bodies however are not directly connected to the bodies hearing these reports.

Table 6.F.3. Assessment of Findings of Land-based Pollution Trends from Land-based Pollution Thematic Area

Land-based Pollution Item	General Findings	Assessment
Domestic Wastewater		
Sewerage and treatment	<ul style="list-style-type: none"> Less than 15% of the Philippine population is connected to sewer systems and wastewater treatment facilities as of 2015 	<ul style="list-style-type: none"> While there is no data per WQMA, the over-all trend shows the Clean Water Act's various schemes are <u>largely ineffective</u> in addressing these domestic wastewater items given the data provided
BOD loading	<ul style="list-style-type: none"> 33% of total BOD load from domestic sources BOD load draining to SCS – up 38% from 2000 TDA 	
Nutrient loading	<ul style="list-style-type: none"> 140,000 ± 20,000 tons of nitrogen and 24,000 ± 20,000 tons of phosphorus annually to water bodies, with a significant portion eventually reaching coastal waters of the West Philippine Sea 	
Microbial contamination	<ul style="list-style-type: none"> Fecal coliform (FC) levels in major urban waterways such as the Pasig River frequently exceed 105 to 106 MPN/100mL, well above the 200 MPN/100mL standard for recreational waters. While infrastructure developments have increased capacity to treat septage, the treatment capacity is <1 % of the wastewater volume processed daily in Metro Manila, as scaling would remain critical. 	
Wastewater from Industrial Effluents		
	<p>According to the DENR-EMB (2020) National Water Quality Status Report, while industrial discharges contribute a smaller volume than agricultural and domestic sources, their environmental impact is significantly greater due to their toxic composition. Industrial effluents often</p>	<p>While there is monitoring of this item as per the National Water Quality Status Report referred to, the assessment of its bigger environmental effect is something that needs to be done, at the national level.</p>

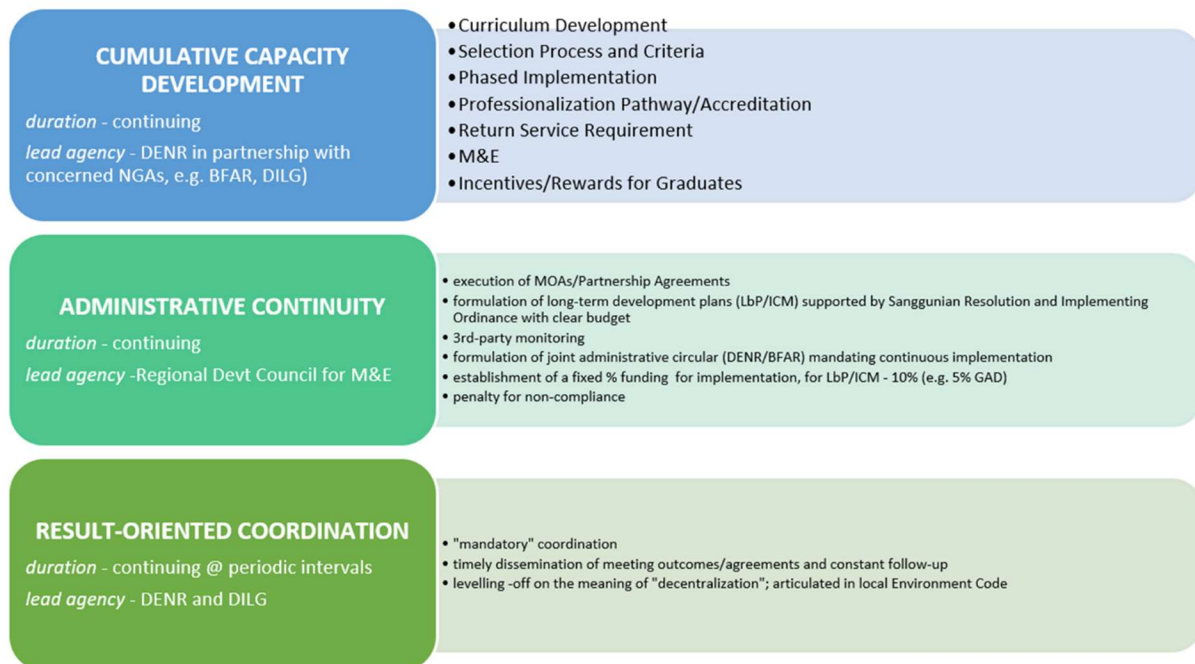
	contain heavy metals, oils, and hazardous chemical wastes.	
Agricultural run-off		
Fertilizer use	From 2000 to 2022, nitrogen (N) use - 64 % increase phosphorus (P) use - 224 % increase potassium (K) use - 223 % increase	As per Clean Water Act mandate, the Department of Agriculture does not appear to have addressed this in a significant manner.
Pesticide use	Between 2000 and 2022, total pesticide use in the Philippines rose steadily from approximately 50,000 tons/year of active ingredient (a.i.) to over 85,000 tons/year, while application rates per hectare climbed from 5.8 kg a.i./ha to 15.2 kg a.i./ha (FAO, 2025).	
Solid Waste and Marine Litter		
Waste generation	The total municipal solid waste (MSW) in 2016 was around 40,000 tons/day nationwide (Talavera et al., 2024) compared to 37,400 tons/d in 2012. This corresponds to about 0.40 kg per capita per day.	The DENR appears to be struggling to address these concerns, through the years.
Waste composition	Biodegradable/organic waste (e.g., food and yard waste) dominates the waste stream (~50–55%) (EMB, 2019). Plastic waste is roughly 10–11% of MSW by weight, and mismanagement has become a national crisis	
Plastic waste leakage	PH a as a top source of ocean plastics (e.g., ~0.75 million tons of mismanaged plastic enter the ocean each year (WB, 2021).	
Hazardous Waste		
	Data from 2012-2023 showed that the peak amount of hazardous waste generated was in 2013, amounting to 8,976,955.99 tons. It has declined to a mere 238,257.92 tons in 2023.	This is one bright spot in an otherwise bleak picture of performance in all other areas.
Oil Pollution		
	Between 2000 and 2021, 467 oil spills were recorded in Philippine waters. Of these, 14 were classified as major spills (>10,000 liters), 62 as medium spills (1,000-10,000 liters), 306 as minor spills (<1,000 liters), while 85 were reported with undetermined volumes (Alea et al., 2022).	These events are usually considered “acts of God” but the clean-up and compensation for the damage caused is another item that must be further assessed.
Atmospheric Pollution		
	The majority (56%) of these air pollutants is attributed to mobile sources such as cars, motorcycles, trucks, and buses, while thirty-five percent (35%) was contributed by stationary sources such as power plants and factories. The rest (9%) were from area sources such as construction activities, open burning of solid wastes, and <i>kaingin</i> in the upland, among others.	Not clear from the data if the trend is increasing or decreasing

Annex 6.G. Recommendations on Governance from the National Validation Workshop, 12-14 Nov 2025

Breakout session questions:

1. How do we build the capacity of LGUs towards an effective and sustained pollution control and management and ICM implementation?
2. How do we ensure continuity in the efforts of national agencies and LGUs?
3. What are the ways to ensure effective coordination across various agencies and various efforts in many areas in relation to pollution control and management ICM?

Key Recommendations generated from the breakout session questions:



From the discussions that preceded the break-out session, it was emphasized by the participants that the capacity development efforts to enhance governance over-all should be one that may be described as **CUMULATIVE** where the trainings are of a continuous character preferably with the same set of participants for the duration of the capacity building effort. Then, to avoid the pitfalls commonly experienced when political leaders at the local level may have differing ideas from their predecessors who may have initiated good governance efforts, it was suggested to zero in on **ADMINISTRATIVE CONTINUITY** such that whatever may be the outcomes of political exercises that result in changes in political leaders, at least all the efforts initiated from previous local leaders should at least be guaranteed a higher degree of stability and build-up of implementation to ensure that whatever gains may have been secured are not set aside just because it has not been initiated by the current political leader. Finally, given that coordination between and among various local authorities including also vis-à-vis local and national authorities, the participants underlined the importance of not doing coordination for coordination's sake but to instead have that goal-focused approach or **RESULT-ORIENTED** effort to it all in the interest of maximizing whatever activities that may be initiated in the area of coastal and marine management and land-based pollution.

In addition to the above recommendations shown in the graphic, there were further recommendations on fisheries and science, technology and innovation but the important area of intervention that cuts across these key

recommendations above involve the matter of incentives for good behavior which range from mobilizing resources so that the good practices for coastal and resource management are sustained and these resources range from those that are available at the international level like the funds provided by the Green Climate Fund and the Fund for Responding to Loss and Damage under the UN Framework Convention on Climate Change or payments for ecosystem services which are established at the local level by resource users and affected communities. Then there is also the usual application of sanctions provided by law to erring local government units especially those that involve the misuse of public easements on coastal and foreshore sites and locations including referral to the Environmental Ombudsman.

There was also a bonus question relating to what other areas may be added for consideration in the purported adoption of a national legislative measure on the BLUE ECONOMY (as typified by House Bill No. 1158 by Rep. Benitez under the 20th Congress) and the group suggested two items: one, how to connect communities outside of protected areas; and two, how to incentivize and organize the communities such that they may be able to actively participate and be involved in all the other components of the Blue Economy.

Annex 6.H. Supplementary Materials

Progress in Sustainable Development Goals

Supplementary Material A

Progress on Sustainable Development Goals

The Philippines is on track towards meeting SDG Goal 14.5 conservation of coastal areas as well as Target 14.5.1 on establishment of marine protected areas (Philippine Statistics Authority, 2025). Although in 2020, the country reported protecting 9.7% of its seascapes, narrowly missing its commitment under the Convention on Biological Diversity's Aichi Biodiversity Targets to protect 10% of coastal and marine areas by 2020 (Chavez, 2021)

SDG 6.5.1: Integrated Water Resources Management (IWRM)

The Philippines' progress on IWRM, which connects water management from source to sea, is crucial for coastal health. The most recent official assessment submitted to the UN-Water platform (2021 data) scored the Philippines at 51 out of 100 for IWRM implementation. (UN Water, 2023) This indicates that while the country has a foundational framework, including the National Water Resources Board (NWRB), the integration between national policies and local government implementation is not yet fully effective. **The lack of a unified governing body for water** remains a significant legislative hurdle to advancing integrated management.

In spite of these seemingly established frameworks and structures and apparent progress in attaining the SDG Goals, this institutional infrastructure for coastal and resource management is still constrained by a **continuing lack of integrated and collaborative efforts** (White, et.al., 2006), **weakness in enforcement** due to several factors such as resource scarcity (Milne and Christie, 2005), **capacity gaps and legal hurdles** such as the documented lack of training and expertise among many local enforcers, police, public prosecutors, and judges regarding the technicalities of environmental law (Galveia and Macusi, 2025), and **socio-economic realities** where many impoverished, small-scale fishers, engage in illegal or destructive fishing methods as a matter of survival, especially in the face of declining legal catch confirmed by a recent BFAR report on illegal, unreported and unregulated (IUU)IUU fishing where the majority of local government units reported that illegal fishing remained to be a critical challenge as there are many repeat offenders who might not have faced significant accountability or received only minor sanctions. (DA-BFAR, 2024). Underpinning all other constraints is the fundamental and chronic failure to adequately finance coastal and marine management which is a marked need and while considerable financial support has been provided by the international development community, this funding does not directly address the question of financial sustainability (Quieta, 2016),

Supplementary Material B

Assessment of Governance Effectiveness

Reduction in Ecosystem Stressors

Changes in peoples' behavior

The land-based pollution thematic chapter did not directly measure whether any changes related to the actual behavior of people, the over-all trends in domestic wastewater, wastewater from industrial effluents, agricultural runoff, solid waste and marine litter, hazardous waste, oil pollution, including atmospheric pollution indicate a worse situation compared to the last TDA in 2000. The details of this assessment can be seen in **Annex 6.A, Table 6.A.3**.

Despite these findings, the updated Philippine submission on its fulfillment of the SDG Goals, points to the accomplishment of improved water quality for the indicators for dissolved oxygen and biochemical oxygen demand (Philippine Statistics Authority, 2025):

target 6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally			
6.3.2.p1	Proportion of monitored bodies of water with good water quality based on the water quality guidelines of the Clean Water Act ^{2/}			
6.3.2.p1.1 Dissolved Oxygen (DO)	31.0 2016	82.0 2022	100.0 2030	National Water Quality Status Report, EMB-DENR
6.3.2.p1.2 Biochemical Oxygen Demand (BOD)	37.0 2016	70.0 2022	100.0 2030	National Water Quality Status Report, EMB-DENR

Figure 6.H.1. SDG Score card in the Philippines (PSA, 2025)

Changes in Ecosystem States

The key findings of the ecosystems thematic area indicate that the overall condition of the reef ecosystems in the covered areas is considered **fair**, with **localized recovery** occurring within well-managed marine protected areas (MPAs), where coral cover has **shown sustained increases between 2006 and 2022**. In contrast, reefs **outside MPAs remain highly degraded**, particularly in areas experiencing intense fishing and tourism activities, where coral cover has declined dramatically—from above 50% in 2006 to below 30% by 2016 in some sites. One notable finding from the reef ecosystems thematic area is that climate change is an additional and escalating driver of reef degradation in these areas. Increasing sea surface temperatures, more frequent typhoons, and recurring bleaching events exacerbate existing pressures.

As to mangrove, the overall trend continues to **fluctuate**, where it is noted that for the last 20 years, from 2020, a negative change (-35,040 ha) was documented in 2010 with only a minimal positive change (+34,221 ha) recorded in 2020.

As to seagrasses, the entire Philippines seagrass ecosystem, where 85% of which is confined in the South China Sea, showed a **30 to 50% decline** in cover over the past years, particularly from the northwestern part of the island.

As to fisheries thematic area (Garces, 2025), the key findings indicate: (i) overfishing and depletion of fish stock in coastal waters; (ii) IUU fishing; (iii) environmental degradation (pollution and coastal habitat destruction); and (iv) climate related impacts on fisheries.

These are happening amidst increasing exposure of the country to climate and natural hazards (Agaton and Ancheta, 2025).

Supplementary Material C

Gap Analysis

Gaps in Institutional Frameworks and/or in their Implementation

A major gap relates to the jurisdictional barrier between fisheries and the environment and between the DA-BFAR and DENR. The DA-BFAR's principal competencies and resources are focused on fisheries and fisheries-related activities but do not extend to other maritime activities that impact on fishery resources, such as shipping, coastal infrastructure development, etc. The DENR meanwhile has a much broader mandate and residual powers for environmental management and resource management, but has no specifically empowered and enabled marine office,

although it carries out a Coastal and Marine Ecosystems Management Program as one of other programs implemented by the DENR-BMB (Arceo, et.al, 2024).

Both the DENR and DA-BFAR have mandates to establish area management measures, but while the DA-BFAR has the power to establish fishery reserves and sanctuaries in national waters, such measures are within the purview only of the cities and municipalities within municipal waters extending 15 km from the shore. More comprehensive protected landscape and seascape areas are established through a separate multisectoral and inter-agency process managed by the DENR (Batongbacal, 2024).

The challenge in this overlap in mandate between the DENR and BFAR relates to how the two agencies may fully cooperate and mutually integrate each other's agency priorities within their respective plans, programs and activities. The opportunity for collaboration between these two agencies lies in both agencies actively pursuing conservation efforts of the coastal and marine ecosystem through a ridge-to-reef approach while simultaneously addressing the ecosystem challenges of meeting productivity and food security concerns. The PBSAP provides the policy platform for these two agencies to weave together and coordinate their respective specific policies and measures to achieve the common targets of the KMGBF while taking steps to build the capacity of LGUs as well as local communities with the help of civil society organizations and the private sector to achieve identified achievable targets.

The fish and fisheries thematic area (Garces, 2025) recently pointed to the threat of a local court ruling affirmed by the Supreme Court in 2024 (*Mercidar Fishing Corporation v. BFAR*, G.R. No. 290929) which nullified the current legislative basis for limiting fishing in municipal waters to municipal fishermen, the effect of which is to let big commercial fishing operators compete with small marginalized fishermen. The problem with this is that allowing commercial vessels to operate within municipal waters jeopardizes the livelihoods of thousands of subsistence fishers and accelerates the depletion of already fragile fish stocks. The potential impacts on small-scale fishers and municipal waters may include: (i) shrinking fishing grounds of municipal fisherfolk; (ii) further depletion of fish stocks in coastal areas; (iii) exploitation or destruction of marine protected areas (MPAs) and fish sanctuaries; and (v) intensify competition over the fisheries resources between municipal fishers and commercial fishers.

Following discussions and consultation at **the Philippines NTDA Inception Workshop** more specific institutional gaps in relation to the project sites were identified mostly in the area of law enforcement and coordination among the various law enforcement units at the local government level. This may be addressed by appointing a local environment and natural resources officer or strengthening the law enforcement auxiliary group (the *Bantay Kalikasan*).

Assessment from the Policy Cycle Perspective

Existing ICM policies are in various stages of implementation and overall the governance architecture for were assessed as medium risk for completion (refer to Table 6.2).

7. Conclusion of the National TDA Report

7.1 Meeting the TDA Objectives

The Transboundary Diagnostic Analysis (TDA) is a key component of the Strategic and Action Plan (SAP) for the marine and coastal environment of the South China Sea and Gulf of Thailand Large Marine Ecosystem, serving as the scientific assessment and technical foundation for identifying and understanding the root causes of environmental issues that transcend national borders. This current Transboundary Diagnostic Analysis (TDA 2.0) builds on the foundation of the first TDA for the South China Sea developed in 2000, which provided a baseline understanding of priority transboundary environmental concerns with the corresponding policy recommendations. While the earlier effort focused on identifying and prioritizing key threats such as overexploitation of fisheries, habitat degradation, and land- and sea-based pollution, the present TDA 2.0 updates the status of these issues and further identifies recent and urgent challenges toward shaping forward-looking solutions.

To ensure scientific accuracy and policy relevance, the TDA 2.0 underwent a national multi-stakeholder validation workshop on November 12-14, 2025, engaging technical experts and decision-makers from national agencies, local government units, academe and research institutions, and civil society groups. Through plenary discussion and facilitated review for each TDA component, stakeholders validated data inputs and supplemented additional information evidence with local monitoring and management experience. The workshop confirmed that the priority concerns identified in the TDA remain persistent and interconnected across Philippine coastal provinces bordering the SCS LME. Participants further affirmed that several of these pressures transcend jurisdictional boundaries, highlighting the need for harmonized monitoring systems and stronger boundary cooperation under the SAP 2.0.

The primary objective of the TDA 2.0 is to generate an updated, evidence-based assessment that will directly inform the formulation of a new Strategic Action Programme (SAP 2.0) for the South China Sea and the Gulf of Thailand LME. It harnesses accumulated scientific knowledge, monitoring results, and governance experience to produce an updated, indicator-based assessment of how climate change, coastal development, and pollution are affecting the resilience of marine and coastal ecosystems.

The updated TDA has effectively met its stated objectives by systematically identifying and characterizing the major environmental concerns and risks affecting Philippine waters within the South China Sea Large Marine Ecosystem (SCS-LME). Across its five components - socio-economic and climate, pollution, ecosystems, fish and fisheries, and governance - the assessment frames these issues within the context of the triple planetary crisis: climate change, nutrient and plastic pollution, and biodiversity loss. To exemplify, the socioeconomics and climate component underscores the high exposure of localities bordering the Philippine waters in the SCS-LME to multiple hazards and disasters. These risks are not only a consequence of the Philippines' geographic location but are also exacerbated by human-induced pressures, including continuous land conversion, unsustainable aquaculture, agricultural, and fishing practices, mining and quarrying, weak waste management, urban congestion, and pollution. These drivers collectively accelerate environmental degradation and erode natural buffers against hazards. As a result, ecosystem services, populations and economic assets are becoming increasingly exposed and at risk across different localities.

This comprehensive analysis has enabled the identification of the root causes, immediate impacts, and key driving forces behind ecosystem degradation, thereby providing a scientifically robust foundation for the SAP 2.0. While some data are sparse and inaccessible, others remain limited, particularly in relation to long-term time series and harmonized methodologies. Nonetheless, TDA 2.0 provided a reliable evidence base that can guide national and regional interventions in line with the updating of the SAP.

Through this approach, the TDA 2.0 positions itself not only as a retrospective assessment but also as a forward-looking decision-support tool. It provides governments and regional bodies with a shared, science-based foundation for policy coherence, investment prioritization, and international collaboration. By aligning national analyses with regional and global frameworks such as the Sustainable Development Goals, the Convention on Biological Diversity's Kunming-Montreal Global Biodiversity Framework, and current transboundary cooperation in East and Southeast Asia, the TDA 2.0 ensures that the forthcoming SAP will be responsive to current challenges while preparing countries to address emerging risks and opportunities in the future.

To further strengthen consensus and stakeholder ownership, the national validation workshop confirmed that the major environmental concerns assessed in the TDA remain reflective of on-ground realities across the Philippine coastal provinces bordering the SCS-LME. Stakeholders validated that the pressures affecting ecosystems and fisheries are strongly linked to pollution, land-use change, fragmented governance and insufficient institutional capacity, and socio-economic vulnerability from climate and environment-related threats. Moreover, multiple concerns were reaffirmed to be transboundary in nature such as nutrient and wastewater pollution, marine plastic, IUU fishing, biodiversity loss in shared migratory habitats, and degradation of wetland and coastal ecosystems that serve as regional migration corridors.

7.2 Key Conclusions and Crosscutting Interactions

The TDA 2.0 underscores that the environmental challenges in the Philippine portion of the South China Sea Large Marine Ecosystem (SCS-LME) are deeply interconnected, cutting across ecosystems, sectors, and governance scales. Key conclusions point to the convergence of ecological, socio-economic, and institutional pressures that reinforce one another, magnifying risks and complicating solutions. These dynamics are further framed within the triple planetary crisis which not only accelerate ecosystem degradation but also heighten risks to human well-being, economic resilience, and institutional effectiveness.

The conclusions presented below are strengthened by the outcomes of the national multistakeholder validation workshop, which confirmed that the priority environmental concerns identified in the TDA 2.0 are both persistent and increasingly interconnected across Philippines coastal provinces bordering the SCS-LME. Stakeholders reaffirmed that many of these concerns including pollution flows, illegal unreported and unregulated (IUU) fishing, and biodiversity loss in ecologically linked habitats, extend beyond national jurisdiction, underscoring the necessity of harmonized monitoring, regional management measures, and shared investments under the forthcoming SAP 2.0.

1. Ecosystems remain under continued pressure from multiple drivers. Mangroves, seagrasses, coral reefs, and wetlands continue to experience habitat loss and degradation due to coastal development, pollution, destructive fishing, and weak enforcement. These pressures erode the ecological resilience of coastal systems, diminishing their capacity to act as natural buffers against climate change and to sustain fisheries and livelihoods. The cumulative degradation of these ecosystems exacerbates the exposure of coastal populations to hazards and reduces the potential for blue economy opportunities that rely on healthy coastal and marine systems
2. Information on coastal wetlands in the Philippine waters within SCS-LME, particularly mudflats and tidal flats, remains limited. These ecosystems are still poorly studied, with few biodiversity assessments and gaps in understanding their ecological and physical functions. Advancing research and assessments in these areas will strengthen evidence-based decision-making, improve site prioritization, and enhance the integration of tidal flats into conservation, management, and climate adaptation strategies.
3. Pollution, particularly nutrient loading, sediment mobilization, plastics, and untreated wastewater, remains a systemic stressor with impacts that cascade across local and regional scales. While the Clean Water Act (2004) provides a comprehensive framework, its enforcement and compliance remain fragmented. Gaps in wastewater treatment infrastructure, insufficient monitoring systems, and the seemingly inaccessible national

effluent database weaken the country's ability to manage pollution sources effectively. These deficiencies contribute to declining water quality, ecosystem degradation, and transboundary spillover effects that affect the wider SCS-LME.

4. The findings also reveal that while human development indicators are improving, socio-economic progress remains uneven, with growth concentrated in urban centers, while rural and island provinces remain underutilized. At the same time, inefficient land-use planning, unsustainable resource management, and rapid urban expansion are amplifying the exposure of populations and economic assets to natural and climate-related hazards. These patterns highlight the interdependence of human well-being, economic growth, and environmental resilience. Moving forward, fostering integrated approaches that balance inclusive development with climate adaptation and sustainable resource management is highly called for. By strengthening these linkages, the Philippines can further reduce risk, enhance resilience, and more efficiently harness the blue economy as a driver of sustainable development and regional cooperation.
5. Fisheries resources in the SCS-LME are experiencing unsustainable fishing leading to depletion of fish stocks and declining fish catch, as well as biodiversity loss. Illegal unreported and unregulated (IUU) fishing (i.e., encroachments of commercial boats in municipal waters and potential impacts of fishing activities in transboundary waters in fishing grounds and areas within Philippine territory) and lack of compliance to fisheries regulations also contribute to unsustainable fisheries situation. Resource use conflicts in coastal waters have resulted in environmental degradation from water pollution and habitat destruction (coral reefs, seagrass beds, mangroves including climate-related shocks (e.g., typhoons) contributes to the challenges to maintaining productive fisheries habitats and healthy fish stocks.
6. Fragmented and weak institutional coordination remains a critical barrier. Despite progress since the first TDA (2000) with the enactment of the Clean Water Act (Republic Act No. 9275), Fisheries Code (Republic Act No. 8550 as amended by Republic Act No. 10654), Wildlife Act (Republic Act No. 9147), Expanded National Integrated Protected Areas System Act (Republic Act No. 11038), and adoption of Integrated Coastal Management through Executive Order No. 533 series of 2006, key governance challenges include weak enforcement, competing commitments for coastal and marine conservation, reliance on external funding for sustainability, and socio-economic pressures driving destructive practices. This makes imperative the urgent need for strengthened and consistent implementation, enhanced inter-agency coordination, community empowerment, and sustainable financing that could be integrated into a coherent strategic action programme anchored on regional cooperation taking into account current international biodiversity and climate targets and the SDGs.
7. These crosscutting challenges directly affect national strategies such as the Philippine Biodiversity Strategy and Action Plan (PBSAP), which emphasize coherent, ecosystem-based, and multilevel governance to fulfill the country's commitment under the Convention on Biological Diversity. Weak coordination between national and local levels, as well as across different agencies, together with limited program continuity and inadequate resources, undermines the alignment of PBSAP targets with global frameworks, including the SDGs and the Kunming-Montreal Global Biodiversity Framework. Strengthening institutional coordination across sectors at the national level and among national, provincial, and local governments is critical to ensure that PBSAP objectives are aligned with regional and global biodiversity commitments.

Overall, this updated TDA highlights that ecological degradation, pollution, socio-economic pressures, climate risks, and governance fragmentation are not isolated issues but reinforcing drivers that demand integrated solutions. Addressing them requires strong cross-sectoral coordination, long-term investment, and sustained regional cooperation to ensure that both national priorities and transboundary commitments are effectively met.

7.3. Patterns of Risk Among Spatial Units of Analyses and at Country Scale

The assessment revealed distinct patterns of risk across pollution, socio-economic and climate factors, fisheries and ecosystems. These risks vary among provinces but are interconnected, reflecting both localized pressures

and transboundary drivers within SCS-LME. This spatial analysis highlights four (4) key areas along the Philippine waters within SCS-LME namely, Manila Bay, Lingayen Gulf in Pangasinan, Batangas Bay, and west coast of Palawan.

A. Pollution

Urban and industrial centers have emerged as pollution hotspots. Nutrient loading, sediment mobilization, plastics and untreated wastewater continue to affect water quality and coastal and marine ecosystems. While the Clean Water Act provides a strong policy framework, gaps in treatment facilities, monitoring, and data accessibility continue to challenge effective management and enforcement.

- Manila Bay remains the most critical hotspot with excessive coliforms, nutrients and heavy metals concentrated by its semi-closed waters.
- Lingayen Gulf receives substantial riverine inputs from agriculture, upstream mining, and aquaculture.
- Batangas Bay, including Verde Island Passage, experiences localized oil residues, trace metals, and industrial waste that place pressure on globally important reefs.
- Palawan generally faces lower risks but is showing rising coliform levels near tourism areas such as El Nido and Coron.

B. Socio-economic and Climate

The National Capital Region (NCR), in which Manila Bay is situated, and nearby provinces face the highest exposure of people and assets to hazards, while remote provinces such as Batanes show the lowest.

C. Fisheries

Overfishing, habitat loss, and IUU fishing persist as major pressures, particularly in Fisheries Management Areas 5 (Palawan and Occidental Mindoro) and 6 (Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Bataan, Bulacan, Pampanga, Zambales, Batangas, Cavite, Occidental Mindoro). These drivers reduce fish catch, undermine food security, and accelerate biodiversity decline in productive fishing grounds.

D. Ecosystems

Mangroves and wetlands (mudflats and tidal flats), coral reefs, and seagrass beds remain under stress from conversion, reclamation, destructive practices, and pollution. Palawan, Batangas, and Pangasinan were identified as high-priority areas, given their high conservation and socio-economic value alongside elevated risks. Medium and low priority provinces require adaptive measures and continuous monitoring to prevent escalation of threats. Across the assessment, Manila Bay, Lingayen Gulf, Batangas Bay and the Verde Island Passage, and Palawan, emerged as critical focal areas, reflecting both the intensity of pressures and their importance to national and regional sustainability.

Risks are varied yet interconnected across sites, with pollution in urban centers, declining fisheries, and vulnerable ecosystems. At the national scale, the convergence of risks in Manila Bay, Lingayen Gulf, Batangas Bay, and Palawan underscores the urgency of focusing interventions where ecological and socioeconomic stakes are highest. These shared challenges transcend boundaries, reinforcing the need for collaborative action across the SCS-LME.

The validated list of environmental concerns categorized as national and transboundary is summarized as follows:

a. National Concerns:

- Land and sea-based pollution
- Habitat degradation of mangroves, seagrass beds, coral reefs, and wetlands

- Limited data and research on wetlands
- Unsustainable fisheries and resource use conflict
- Weak enforcement and fragmented governance
- Limited resources (i.e., manpower, technical knowledge and skills) to implement policies and programs
- Limited institutional capacity

b. Transboundary Concerns:

- Marine plastic debris
- Oil spills and ship-borne pollution
- Riverine pollution and nutrient loading
- Shared marine resources contamination
- IUU fishing (encroachment of commercial fishing vessels in municipal waters and operations of flagged fishing vessels within Philippine waters)
- Overfishing and depletion of fish stock in coastal waters
- Habitat destruction and environmental degradation
- Species loss and biodiversity threats
- Climate change impacts

7.4 Target Audience

TDA is designed to serve various audiences whose engagement is crucial to the success of the forthcoming SAP 2.0. These audiences span national, local, research, civil society, private sectors, and international cooperations and development partners each with distinct but complementary roles in addressing the transboundary environmental challenges of the SCS-GOT.

- **National Government Agencies:** Policymakers and agencies directly responsible for coastal and marine resource management, including the Department of Environment and Natural Resources (DENR), Department of Agriculture (DA), Department of Economic, Planning and Development (DepDEV), DTI, DFA, DOTr, DOST, DILG, DHSUD, Department of Energy (DOE), Department of Tourism (DOT), Department of Public Works and Highways (DPWH), Climate Change Commission, and other relevant agencies. The TDA provides them with evidence-based analysis to guide remedial legislation, strategic planning and implementation, inter-sectoral coordination, and budget allocation.
- **Local Government Units (LGUs):** As frontliners in natural resource management and service delivery, LGUs play a critical role in translating national policies into concrete local actions. The TDA can support LGUs by contextualizing local initiatives within broader SAP 2.0 objectives and international commitments, enabling integrated and ecosystem-based management approaches at the community level that enhances their overall well-being.
- **Research institutions and the academe:** Universities, technical institutes, and think tanks are vital in addressing scientific data gaps, advancing monitoring systems, and producing new knowledge. The TDA highlights research priorities across its components and offers a roadmap for scientific inquiry that can inform adaptive management and innovation.
- **Non-governmental organizations (NGOs) and civil society organizations (CSOs):** These groups can leverage the findings of the TDA report to strengthen advocacy, promote accountability, advance community-based resource management and innovative solutions.
- **Private sector:** Industries engaged in fisheries, aquaculture, shipping, and other Blue Economy sectors are both users and stewards of coastal and marine resources. The TDA provides them with a platform to identify potential business opportunities and align their practices with sustainability principles through corporate

social responsibility initiatives, public-private partnership, compliance with environmental regulations, and investments in nature-based solutions.

- **Regional and International Bodies and Development Partners:** Multilateral institutions such as the Global Environment Facility (GEF), United Nations Environment Programme (UNEP), UNOPS, UNDP, Coordinating Body on the Seas of East Asia (COBSEA), PEMSEA, Southeast Asian Development Center (SEAFDEC), ASEAN sectoral bodies, and other development partners are central to providing financial, technical, and policy support. The TDA serves as a scientific reference and decision-support tool to align national priorities with regional and global frameworks, foster transboundary cooperation, and leverage resources for SAP 2.0 implementation.

7.5. Future Indicator-based Environmental Assessments

Future assessments should prioritize the following indicators:

A. Socio-economic and climate:

- Maritime disasters, including oil spillage
- Coastal infrastructure developments (reclamation projects, coastal highways/roads, boulevard,
- Encroachment of informal settlers
- Application of local ecological knowledge in disaster risk reduction and management

B. Pollution:

- Coastal and Marine Water Quality and Pollution Index
- Riverine Pollution Load Index
- Eutrophication Index
- Risk Quotient of Microplastics, Persistent Organic Micropollutants, and Emerging Contaminants
- National Industrial Waste and Effluent Central Database

C. Ecosystems:

- Coastal wetland (i.e. mudflats and tidal flats) biodiversity and integrity index
- Ecosystem health monitoring index
- Habitat condition and connectivity index
- Integrated ecosystem data and accessibility
- Ground-based ecological assessment
- Standardized marine habitat and wildlife monitoring protocols
- Ecosystems resilience and vulnerability indicator

D. Fish and Fisheries:

- Trends in fish catch by FMA/province, sub-sector, gear and species
- Trends in fishing effort by FMA/province, sub-sector
- Stock status by FMA/fishing ground
- Coastal habitat health/status
- Climate impacts to fish and fisheries

E. Governance:

- Policy implementation and accomplishment
- Coordination among national, provincial and local institutions
- Capacity and resources of LGUs for integrated coastal management
- Adequacy and sustainability of financing mechanisms

- Availability and quality of data collection and reporting
- Stakeholders' participation and engagement
- Best/Innovative practices for replication