Desk Review on Nutrient Pollution as a Regional and Transboundary Challenge in the East Asian Seas Region

March 2021

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Suggested citation:

Coordinating Body on the Seas of East Asia (2021). *Desk Review on Nutrient Pollution as a Regional and Transboundary Challenge in the East Asian Seas Region*. Bangkok: United Nations Environment Programme.

List of Acronyms

AMWQC	ASEAN Marine Water Quality Criteria
BOBLME	Bay of Bengal Large Marine Ecosystem
BOD	Biochemical Oxygen Demand
BWM	International Convention for the Control and Management of Ships' Ballast Water and Sediments
CBD	Convention on Biological Diversity
chl-a	chlorophyll-a
CEP	Caribbean Environment Programme
COBSEA	Coordinating Body on the Seas of East Asia
COD	Chemical Oxygen Demand
CSO	Combined Sewer Overflows
DENR	Department of Environment and Natural Resources - Philippines
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DON	Dissolve Organic Nitrogen
DoNRE	Department of Natural Resources and Environment - Vietnam
DOP	Dissolved Organic Phosphorus
ECS	East China Sea
EMB	Environmental Management Bureau - Philippines
FAO	Food and Agriculture Organization of the United Nations
FIO	First Institute of Oceanography - China
GEF	Global Environment Facility
GNC	Global Nutrient Cycle
GPA	Global Programme of Action
GPNM	Global Partnership on Nutrient Management
HAB	Harmful Algae Bloom

ICWQM	Integrated Catchment Water Quality Management
IG	Intergovernmental
IMO	International Maritime Organization
INMS	International Nitrogen Management System
LBS	Land-Based Sources
LMEs	Large Marine Ecosystems
MARPOL	The International Convention for the Prevention of Pollution from Ships
MOEF	Ministry of Energy and Mineral Resources - Indonesia
MOMAF-ROK	Ministry of Maritime Affairs and Fisheries – Republic of Korea
MONRE-TH	Ministry of Natural Resources and Environment - Thailand
MONRE-VN	Ministry of Natural Resources and Environment - Viet Nam
MW	Megawatt
MWQS	Marine Water Quality Standard
N	Nitrogen
NCMD	National Committee for Management and Development - Cambodia
NPA	National Programme of Action
NEA	National Environment Agency
NH_4^+, NH_3-N	Ammonia cation, Amnonia-Nitrogen
NIFS	National Institute of Fisheries Science
NMEMC	National Marine Environmental Monitoring Center - China
NOWPAP	Northwest Pacific Action Plan
NO_3^-	Nitrate
NOx	Nitrogen oxides
NUE	Nutrient Use Efficiency
NWQS	National Water Quality Standards
OMS	Operational Management System

P	Phosphorus
PCD	Pollution Control Department
PO_4^{3-}	Phosphate
PUB	Public Utilities Board
RC3S	Regional Capacity Centre for Clean Seas
RO	Reverse Osmosis
ROK	Republic of Korea
RQ	Risk Quotient
SACEP	South Asia Co-operative Environment Programme
SAP	Strategic Action Programme/Plan
SAS	South Asian Seas
SCS	South China Sea
SMA	Special Management Area
SOC	State of the Oceans and Coasts
SS	Suspended Solid
TP	Total phosphorus
TPLMS	Total pollution load management system
TSS	Total suspended solid
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
VASI	Viet Nam Administration of Seas and Islands
WEPA	Water Environment Partnership in Asia
WQ	Water Quality
WQI	Water Quality Index

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Executive Summary

Nitrogen (N) and phosphorus (P) are essential for all living things. In aquatic ecosystems, they support the growth of algae and aquatic plants that provide food and habitat for fish, shellfish and smaller organisms that live in waterbodies. However, when the coastal and marine environments contain too much N and P, the waters can become polluted. In the East Asian Seas region, chemical fertiliser use, demand for food, industrialisation, and population growth have increased, resulting in the use and discharge of N and P compounds to create more incidences of pollution.

The Coordinating Body on the Seas of East Asia (COBSEA), one of the UNEP-administered Regional Seas Programme, commissioned a desk review from January to March 2021, to compile information on:

- Sources, sinks, fate and transport, and impacts of pollution, focusing on N and P;
- National and regional nutrient reduction commitments, targets, measures, as well as gaps in governance; and
- Existing monitoring and assessment programmes in COBSEA countries.

The information helped to provide a list of suggested regional responses to address better nutrient management and implement pollution control measures that would meet the objectives of "COBSEA's Strategic Directions 2018-2022". COBSEA's Strategic Directions has a component that focuses on land-based pollution with the purpose to "prevent and reduce eutrophication and sedimentation and their impact on the marine and coastal environment."

The main sources of N and P in the region come from agriculture, domestic, and industrial waste, with unsustainable aquaculture as a source in some countries. Sea-based sources of pollution such as from improper ship waste, ballast water discharge, and port operations also contribute to pollution. N and P on land are transported to the coastal and marine areas mainly via rivers, where they are taken up by aquatic organisms, deposited into sediments or remain floating in the water column. The impacts of eutrophication in the region include harmful algal blooms, health hazards to aquatic organisms and human beings, fish and shellfish death, and loss of economic revenue and livelihoods. Hotspots and areas observed to have high concentrations of N and P are found in river mouths, bays, and coastal areas consisting of large cities and industrial areas.

All COBSEA countries have many laws, acts, decrees, and action plans governing environment and water resources protection that specifically address domestic wastewater treatment, industrial and solid waste management, and pollution emmissions and control. There are also laws governing agricultural paractices that deal with chemical fertiliser use and management. The many laws address managing nutrients and wastes in upstream areas before they flow to the nutrient sinks in the

coastal areas. Countries are also signatories to international environment- and pollution-related conventions, and are parties to Strategic Action Programmes/Plans developed under Large Marine Ecosystem projects with management actions addressing elements of land- and sea-based pollution. Despite this, there remain gaps in law enforcement, compliance, and self-regulation to meet standards for pollution and nutrient waste discharge.

All countries have water quality standards and/or and index systems to classify waterbodies and to alert authorities if water quality needs to be improved. Some countries have specific pollution load reduction targets, but this is still rare across most of the region. All countries engage in some aspects of water quality monitoring with a wide range of effort among the countries. Monitoring programmes can still be improved and increased in frequency, but is limited by a lack of resources.

There remain gaps in technical and governance issues to address nutrients and pollution. These include: insufficient data and information, a need to increase awareness and capacity, insufficient understanding of non-point sources of pollution, insufficient waste management approaches, a requirement for stronger law enforcement, and improved institutional harmonisation to coordinate pollution management efforts.

There are many past and existing nutrients management and pollution control efforts carried out in other regions, with global toolsets publicly available. The COBSEA countries can draw upon these as models to adapt for use in the region, as well as access the toolsets for secondary data where needed. As such, the following regional responses are proposed in this report, based on the current situation of nutrients and pollution in the region, and further efforts that are required to better manage nutrient use and control pollution:

- **Monitoring and Assessment** - to fill data and knowledge gaps, manage nutrient leakage from fertiliser use, influence policy and increase support of stakeholders.
- **Research and Knowledge Sharing** - on best practices, nutrient use efficiency (NUE), optimisation and nutrient waste reduction, waste recycling and treatment technologies, estimating nutrient carrying capacity of waterbodies.
- **Data Services and Tools** - to assist countries to adapt and use existing tools and datasets to meet data gaps and respond quickly to incidences of eutrophication.
- **Capacity Building** – on improving agricultural practices, minimising nutrient runoff and waste discharges, P recycling, developing policies to lower animal product consumption and waste production, and improving water quality analytical skills.

- **Regional Hubs -** to provide a service point for knowledge management, data-related needs, offer technical assistance and information on nutrients and pollution management.
- **Integration and Coordination -** to assist countries to meet their commitments to international conventions, build closer linkages with other international programmes to further efforts in information and best practices sharing, increasing stakeholder involvement in pollution management for a more holistic approach and awareness raising of coastal and marine pollution.
- Developing a **regional strategy** or action plan for pollution reduction.
- Establishing an **Expert Working Group** to help prioritise and guide the implementation of regional responses.

1. Introduction

1.1 Nutrient impacts to the coastal and marine environment

Nitrogen (N) and phosphorus (P) are nutrients that are natural components of aquatic ecosystems. N and P support the growth of algae and aquatic plants that provide food and habitat for fish, shellfish and smaller organisms that live in water. These nutrients occur in a variety of forms and can change as they move between the air, water, and soil (see Table 1). However, when too much N and P enter the environment the air and water can become polluted. As the environment is enriched with nutrients, eutrophication occurs. Eutrophication is not always bad and can produce some positive effects as the productivity and fertility from higher nutrient concentrations can lead to higher primary production and higher fisheries production. However, there is a tipping point when too many nutrients will result in pollution.

Over the course of the 20th century, inputs of N and P to coastal and marine ecosystems via river runoff, direct untreated discharge, and atmospheric deposition have increased due to anthropogenic inputs primarily from the use of fertilisers, pesticides, herbicides, combustion of fossil fuels, and industrial and municipal wastes. This has increased the severity and extent of ecological responses to increased nutrient inputs to the coastal and marine environments. There are increased observations of coastal hypoxia, ocean acidification, and toxic algal events that pose serious threats to the health of coastal and marine ecosystems and human beings while reducing the ecosystem's capacity to provide services valued by society. Nutrient pollution of groundwater that millions of people worldwide use as their drinking water source can be harmful even at low levels. Excess N in the atmosphere can produce pollutants such as ammonia and ozone, which can impair our ability to breathe. When excess N returns to earth from the atmosphere, it can disrupt the N cycle and harm the health of forests, soils and aquatic environments.

Table 1. Forms of nitrogen and phosphorus.

Forms of N and P	Description
Ammonia (NH_3) and Ammonium cation (NH_4^+)	These are the primary forms of N in natural waters. When diluted in water, ammonia forms the ammonium cation. Ammonia can be toxic to fish. It is also soluble in water and relatively unstable in most environments. Ammonia is easily transformed into nitrate (NO_3^-) in waters that contain sufficient dissolved oxygen or into nitrogen gas in waters that have no dissolved oxygen.

Nitrate (NO_3^-)	Nitrate another primary form of nitrogen in water bodies. Nitrate is very soluble in water and is stable over a wide range of environmental conditions. It is readily transported in groundwater and streams. An excessive amount of nitrate in drinking water can cause health problems.
Nitrite (NO_2^-)	Nitrite comes from fertilisers through run-off water, sewage, and mineral deposits. High levels in water bodies can stimulate bacteria growth. In some areas of the sea where phytoplankton standing stock is high and nitrate is non-limiting, excretion by these organisms is a major source of nitrite.
Nitrous oxides (NO_x)	NO_x gases are usually produced from the reaction among N and oxygen during combustion of fuels. Agricultural fertilization and the use of nitrogen fixing plants also contribute to atmospheric NO_x, by promoting nitrogen fixation by microorganisms. NO_x in the atmosphere may undergo dry or wet deposition and return to land and water bodies.
Dissolve inorganic and organic N (DIN and DON)	DIN comprises of nitrate, nitrite and ammonium. DON is the N-containing component of dissolved organic matter. In aquatic ecosystems it is part of the biologically reactive nitrogen pool that can degrade water quality in N-sensitive waters. Most DON substances originate from biological matter. DON serves as valuable sources of nitrogen (and carbon) to bacteria and some microalgae.
Phosphates (containing PO_4^{3-})	These is the most common form of P in natural waters. Phosphates are only moderately soluble and compared to NO_3, are not very mobile in soils and groundwater. Phosphates tend to remain attached to soil particles, but erosion can transport considerable amounts of phosphate to streams and lakes.

Dissolved inorganic and organic P (DIP and DOP)	Organic phosphate is found in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate. Organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column).

It is predicted that global anthropogenic N production worldwide will increase by nearly a factor of two during the first half of the twenty-first century. In the past 30 years, synthetic fertiliser (consisting of N, P, and potassium) consumption in East Asia has increased from around 400×10^6 tonnes to a present estimate of over $5,000 \times 10^6$ tonnes (IFA website). However, only 20% of added N results in human food, meaning that 80% is wasted and becomes pollution (UNEP, 2019). It is also predicted that the number of inhabitants connected to a sewerage system will increase by 2 to 4 billion people between 2010 and 2050. Technology is advancing to enhance nutrient removal through wastewater treatment. While this may be costly, efforts for removal are expected to increase by 10%–40% in the next 30 years. Nutrient discharge to surface water is estimated to increase in all scenarios by 10%–70% (from 10.4 Tg of N in 2010 to 13.5–17.9 Tg N by 2050, and from 1.5 Tg P in 2010 to 1.6–2.4 Tg P by 2050) especially in developing countries. A decrease in nutrient discharge worldwide is possible only when wastewater treatment plants contain at least tertiary[1] treatment (van Puijenbroek, 2019). Many Large Marine Ecosystems (LMEs) are hotspots of N loading in both developed and developing countries. Anthropogenic sources account for over half of river dissolved inorganic nitrogen (DIN) load to the coast in 46 out of 63 LMEs. Agricultural activities (fertiliser use and wastes from livestock) is the primary source of river DIN to LMEs in most of Europe and Asia, while sewage and atmospheric deposition also contribute, but to a lesser extent (Seitzinger, 2018).

Southeast and Northeast Asia are rapidly growing regions where changing lifestyles, agricultural and industrial development, and energy demands are impacting the ecosystem services that the natural environment provides. In particular, activities that utilise N and P and/or produce N and P wastes are increasing. Fertiliser as the "invisible" source of pollution has contributed to increased incidences of hypoxia in the Yangtze River estuary bottom waters covering an area of 20,000 km^2. At the same

[1] Tertiary treatment adds a third and final step that is a more advanced and rigorous level of treatment than primary and secondary treatment that typically clean wastewater only enough to discharge safely into the environment. Tertiary treatment should ideally be implemented on wastewater before it is reused, recycled or discharged to the environment. The last step removes remaining inorganic compounds, turbidity, and substances, such as organics, N and P. Most processes involve some type of physicochemical treatment such as coagulation, filtration, activated carbon adsorption of organics, RO, and additional disinfection.

time, the incidences of red tides[2] have increased in coastal areas such as the Gulf of Thailand and the Pearl and Yangtze River estuaries (Dai, 2021). Many countries in Southeast Asia are leading producers of rice, coffee, sugar, palm oil and cocoa. The Southeast Asia Commodity Digest (2015) states that Viet Nam is the world's No. 2 coffee producer, while Malaysia and Indonesia are the world's biggest palm oil producers. All these commodities require inorganic fertiliser. According to FAO (2015), fertiliser consumption in South and East Asia has been increasing at a tremendous pace being one of the largest fertiliser producing and consuming regions in the world. Rising incomes and urbanisation have also led to rapid changes in diets in favour of more grain-intensive food particularly red meat. This causes the need for a substantial increase in the fertiliser demands for grain to feed livestock for food.

Aggressive actions to reduce anthropogenic inputs of N and P to the coastal areas and oceans will be needed to reduce the extent and risk of coastal eutrophication during the course of the 21st century. Technological innovations and management changes need to be implemented, otherwise there will be further increases in nutrient inputs to coastal and marine waters with associated water quality and ecosystem degradation. As nutrients in the coastal and marine environment do not remain static and are transported by various pathways across political boundaries, nutrient pollution is a transboundary challenge and requires a regional response.

1.2 Objective of the study

The Coordinating Body on the Seas of East Asia (COBSEA) is a regional intergovernmental policy forum and decision-making body for the "Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Region." Also known as "The East Asian Seas Action Plan," the document mentions scientific activities leading towards management, including quality assurance for pollution monitoring, biological and ecological effects of pollution, and pollution prevention and control.

COBSEA's Strategic Directions 2018-2022 (COBSEA 2018), adopted by the Second Extraordinary Intergovernmental Meeting in 2018, contains a focus on address land-based pollution with the purpose to "prevent and reduce eutrophication and sedimentation and their impact on the marine and coastal environment." The strategy states some measures to do so may include identifying sources of nutrients, sediments and wastewater (such as from agriculture, aquaculture, municipalities), and the prevention, reduction and control through appropriate measures. It also further identified the following activities to address land-based solutions:

[2] Red tides are a common name for algal blooms which are large concentrations of aquatic microorganisms that discolour the water. Red tides are sometimes also called harmful algal blooms as the algae that causes a red tide produce harmful chemicals that can cause illness and death in humans and other animals.

1. Development of regional guideline for identifying and addressing sources of nutrients, sediments and wastewater;
2. Policy and information exchange, including sharing of outputs, results and best practice from projects addressing land-based sources of pollution, including activities towards implementation of the Strategic Action Programme (SAP) for the South China Sea; and
3. Technical training and capacity building.

As such, a foundational study was undertaken through a desk review and country consultation with the objective to compile information on:

- Sources, sinks, fate and transport, and impacts of pollution, focusing mainly on nitrogen (N) and phosphorus (P);
- National and regional nutrient reduction commitments, targets, measures, as well as gaps in management and governance; and
- Existing monitoring and assessment programmes in COBSEA countries.

This current summary of knowledge on nutrients pollution in the region may serve as a basis for identifying gaps and needs and in this regard support identification and development of regional responses through COBSEA and towards implementation of the pollution component of its strategic directions.

1.3 Methodology

The study was carried out in collaboration with UNEP's Global Partnership on Nutrient Management (GPNM - a global partnership that provides a platform for governments, industry, science community, NGOs, UN agencies and various international and regional organisations to create a common agenda, mainstreaming best practices and integrated assessments, so that policy making and investments are effectively "nutrient proofed" (GPNM website)). The main approaches to source information for this study was a literature review, obtaining information from each country via sending out a questionnaire to appointed focal experts nominated by the National Focal Points of COBSEA, and interviewing experts in the region (Annex 1). The literature review involved a multi-prong approach that included a combination of online research of peer-reviewed literature and regional/global reports by the consultants, drawing on the consultants' personal knowledge of nutrient management initiatives, and obtaining information from the COBSEA Secretariat particularly for UNEP-related programmes. The study was supported by funding from the Ministry of Environment of Sweden towards development of COBSEA's work on nutrients.

National reports on water quality status in English are available for all COBSEA countries, but were not always the most updated information depending on monitoring and reporting efforts, the objective of the programme collating the information. Websites of relevant government agencies usually had some information on environmental monitoring and governance measures, but these were not always in English, hence project-based reports and peer-reviewed international journals were another good source of information. The questionnaires returned by the experts in Indonesia, Philippines, Republic of Korea, Singapore and Thailand were also a good source of information, as were the links shared by the Coordinator for the GPNM.

The questionnaire (attached as Annex 2) asked experts to provide information from their country related to the physical and chemical status of nutrients, current policies and actions on pollution control, gaps in research, management and governance, country and regional needs, and suggestions for further pollution control measures. Answers to the questionnaire were synthesized with the information from the literature review to prepare this report.

In addition, planning discussions were held between the consultants and COBSEA Secretariat to agree on the approach for this study, the convening of the Introductory Webinar (held on 14 January 2021) and the Virtual Workshop (held on 3 March 2021). The Introductory Webinar explained the nature of the work to the focal experts and other participants, the work schedule, expected contributions from experts, and expected outputs of the consultancy.

The Virtual Workshop provided an opportunity for experts and COBSEA Focal Points to review the draft report, provide their final inputs, and agree on the main content of the report. This report thus contains the information gathered from experts, secondary sources publicly accessible, and inputs from the two online meetings.

2. N and P Pollution in the East Asian Seas Region

This chapter summarises the status of N and P and their influences in causing pollution in each COBSEA country. Information was provided by experts and also sourced from the best available literature publicly available: Information is provided on:

1) Nutrient sources and sinks;
2) Transport pathways;
3) Fates of N and P;
4) Impact of nutrients on environmental status, ecosystem services, social and economic situation; and
5) Hotspots.

The main sources of N and P pollution to the coastal and marine environment in the COBSEA countries come from agriculture, domestic and industrial waste. Aquaculture is a source but its impact varies among and within countries depending on the scale and sustainability of the farms' operations. Sea-based sources of pollution such as from improper ship waste, ballast water discharge, and port operations do also contribute to pollution.

N and P enter the coastal and marine environment mainly through river flow, and may continue to be suspended in the water column, may be deposited into the sediment, and are taken up by marine organisms, thus the nutrient sinks are coastal wetlands, algae, aquatic plants, coastal sediment, and offshore sea beds.

2.1 Cambodia

Nutrient runoff from watersheds and residential wastewater discharge are the main sources of N and P in Cambodia. Domestic waste is still discharged directly into coastal waters without treatment while pollution is exacerbated from port and offshore development (PEMSEA, 2019). Point sources of pollution to wetlands comes from industry and urban sewerage. Agricultural use of pesticides, fertilisers, and herbicides contribute to runoff from watersheds (Heng *et al.*, 2017). The average concentration of TN between 2004 and 2005 showed the highest levels in the eastern parts of the country where there is higher rice production and greater density of humans and livestock. Aquaculture farms are found along coastal areas, but their nutrient load contribution needs further study. Direct waste discharge from factories enters water streams and eventually find their way to the coasts. Open burning of solid wastes releases NO_x to the atmosphere.

The Cambodian coastal zone comprises four provinces namely: Koh Kong, Preah Sihanouk (Kampong Som, Sihanoukville), Kampot, and Kep with several areas along the coast undergoing land reclamation, including a new port development in Kampot. Although not specifically designated as hotspots, these four provinces have seen rapid development (land reclamation, port development, urbanisation) in recent years (EU, 2012). The recreational waters in the centre of Sihanouk town have seen solid waste floating on the water surface. One incident of algal bloom occurred in 2016 in Kep Province, but it could not be determined if the algal bloom was due to nutrient runoff from Cambodia's watersheds or from neighbouring countries (PEMSEA, 2019).

Between 2005 and 2006, the values of TP were highest in the coastal areas of Kampot's Prek Kampong Som and Prek Trapang Ropov (>0.01 mg/l). However, TP concentrations compared to the previous year in coastal streams significantly dropped to approximately 0.01 mg/l, reflecting better conditions of freshwater quality in the coastal area (PEMSEA, 2019).

Poor sanitation leads to economic losses of USD448 million per year, which translates into loss of approximately USD 32 per person. These economic losses are equivalent to 7.2% of Cambodia's GDP in 2005 (World Bank 2018; PEMSEA, 2019).

Sihanoukville is the main coastal town with installed septic tanks for households. There is a community-based solid waste collection system with transfer to landfill and collection of environmental user fees. These practices have increased community awareness and cooperation on waste management, and increased the coverage of and access to solid waste and wastewater management systems (WEPA, 2018).

Kampot town established the Integrated Resources Recovery Center for their integrated solid waste management and recycling in 2013. Household wastes are segregated by individual households and collected separately for recycling, composting and dumping. However, these practices are conducted only in small areas and not throughout the entire town much less throughout the entire province (PEMSEA, 2019). Overall in Cambodia, wastewater treatment is still insufficient and carried out in very localised areas with low efficiency from the on-site system.

2.2 People's Republic of China

In China, the sources of land-based pollution come from agriculture, industry, rivers, sewage outlets, domestic wastes, and aquaculture in semi-enclosed bays with the major pollutants being DIN and DIP (MEE, 2019). In recent years, China's economic advancement has seen improved crop yields with an increase in application of chemical fertilisers since 1980 and an average annual GDP growth rate of 3-5% (Liu, 2015). However, the effective utilisation rate of the fertiliser is low, and the average annual loss rate of N fertiliser in farmlands is 33.3%~73.6%. Fertiliser usage in China accounts for 1/3 of the total usage amount of chemical fertilisers globally, and the application amount per unit area is more than three times the average usage amount in the world (Xin *et al.*, 2012).

Unsustainable mariculture is a pollution source in semi-enclosed bays. Regulating pollutant discharge of mariculture is mainly based on the current discharge requirements of mariculture waters, which is the recommended industry standard issued by the Ministry of Agriculture in 2007 (Wang *et al.*, 2017). Because of the large scale of mariculture and the lack of human resources, it is difficult to supervise and control the discharge of mariculture wastewater.

Of the coastal provinces, Fujian's direct discharge of sea polluted water was largest, followed by Zhejiang. Inorganic N and reactive P are dominant pollutants in main fishery areas, spawning and feeding grounds, migration routes, and aquatic reserves.

Inter-annual increases in nutrient loading have led to increases in phytoplankton biomass in the East China Sea over the years (Zhou *et al.*, 2019). Marine areas receiving the most amount of polluted waters are the East China, South China, and Yellow Seas.

Nutrients are transported to coastal and marine areas mainly via rivers and also through groundwater. Riverine inputs of freshwater and nutrients to the SCS' coastal waters are dominated by the rivers that flow into the Pearl River estuary (Harrison *et al.* 2008; Chen *et al.*, 2009).

Factories contribute to atmospheric transport, while direct discharges are observed through sea-based sources. Nutrients can be further transported by drifting algal bloom, witnessed in the southern part of the Yellow Sea. In summer, macro algae can completely decompose within 80 days, resulting in organic nitrogen increasing from 25% to >90% of the TN in bottom seawaters in the southern part of the Yellow Sea.

Atmospheric input is generally distributed over the entire East China Sea, but during the summer monsoons, river-borne nutrients greatly impact the coastal waters. Although atmospheric deposition of N over the South China Sea as a whole is estimated to be nearly an order of magnitude higher than riverine inputs, deposition is dispersed over the entire Sea with little impact on coastal eutrophication relative to river-borne inputs. The concentration of sea surface chlorophyll-a in the ECS is highest nearshore and decreases in open waters beyond the continental shelf (Yuan *et al.*, 2007, UN Regular Process – World Ocean Assessment).

The frequency of toxic algal blooms has been increasing in the past six decades. The potentially toxic *Noctiluca scintillans* (Pearl River estuary) has been associated with hypoxia and the clogging of fish gills, thus may act as a vector of algal toxins to higher trophic levels and alter food web composition (UN Regular Process). Additionally, as China is the global leader in aquaculture fish and shellfish production, economic impacts from harmful algal blooms are high. Green tide[3], mostly caused by *Ulva prolifera*, are commonly observed in the Yellow Sea and Jiangsu Province from April to September, drifting in a north-easterly direction. They are now present for longer periods with varied distribution in the past ten years (Zhang *et al.*, 2019).

In China, the pollution hotspots can be found in Liaodong and Bohai Bays due to a high level of industrial projects, Jiangsu and Zhejiang Provinces, Hangzhou Bay, Pearl and Yangtze River Estuaries (MEE, 2019). Inorganic N and reactive P are the main pollutants in coastal areas. Of the coastal provinces, river water quality classified in 2019 was as follows:

- Shanghai - excellent
- Zhejiang, Fujian, Hainan – good
- Liaoning, Hebei, Tianjin City, Shandong, Jiangsu, Guangdong, Guangxi lightly polluted.

The coastal areas of Hebei, Guangxi and Hainan were classified as excellent water quality, while Shanghai and Zhejiang were determined to be very poor (MEE, 2019).

2.3 Indonesia

Sources of N and P in Indonesia come from domestic wastewater, industry, aquaculture and agriculture. Domestic wastewater contains large amounts of COD, nutrients, and faecal coliform, and is the largest contributor to surface water pollution in Indonesia. Agricultural wastewater contains COD, nutrients, fertilisers such as urea and triple superphosphate, and pesticides. Industrial wastewater contains a wide variety of pollutants according to the type of industry (UNESCO, 2017).

The questionnaire returned by the expert from Indonesia provided information about the status of N and P in the country. The sources of these nutrients and their transport pathways are shown in the table below and ranked by Low, Medium, and High.

Table 2. Sources of N and P, transport pathway to coastal and marine areas of Indonesia.

Sources	N	P	Transport Pathway to Coastal and Marine Areas
Agriculture	M	M	Agriculture field's canals to the rivers and to the nearest coastal waters. Animal farms also contribute some volume of organic waste to the rivers and end up in the coastal waters.

[3] Green tides are macroalgae blooms often associated with coastal eutrophication. They are large growths and accumulations of algae that absorb large amounts of nutrients.

Aquaculture	M	M	For coastal aquaculture, the disposal of ponds goes directly to the coastal waters.
Industry	M-H	M-H	Disposal canals to rivers and flow to the nearest coastal waters.
Domestic wastewater	H	H	Settlements' disposal canals to rivers, then to the nearest coastal waters.
Non-point source	H	H	Small ditches and canals flow to the rivers and then to the nearest coastal waters.

Source: Questionnaire-Indonesia, 2021.

Organic waste from industry and households has significant impacts on the marine environment. Indonesia also daily produces 0.48-1.29 tonnes of plastic waste plus other materials like paper, polystyrene, rubber, fabric, and metal (PEMSEA and MoEF, 2019) where N from the manufacting process and degradation of products can leak into the environment, Most P comes from detergents.

Most organic wastes accumulate in the estuaries through riverine transport. In the coastal waters, N and P will be decomposed by bacteria into inorganic dissolved N and P. The DIN and DIP are taken up by algae and phytoplankton through photosynthesis forming new organic living materials. Some of the organic N and P will be flocculated with marine debris and suspended sediments then deposited into the bottom of the sea as organic materials. For example, in Jakarta Bay, as studied by van der Wulp *et al.* (2016), most of the N and P are transported by incoming rivers and accumulate in the Bay.

The main impacts of elevated N and P in coastal waters are eutrophication, fish kills, mass fish mortality in fisheries culture areas at some man-made lakes in Java and Sumatera, high biomass algal blooms as seen in Jakarta Bay, elevated primary production, hypoxic or anoxic conditions, increased turbidity and changes in species or community composition.

The hotspots are mostly in the northern coasts of densely populated islands of Java (Jakarta Bay, Banten Bay, Semarang Bay, Pangkah Estuary, Porong Estuary). Other hotspots can be found in the coastal waters of major coastal cities in Indonesia such as at Makassar Coastal Waters (South Sulawesi Province), Musi River Mouths (South Sumatera Province), and in almost every big coastal city in the country.

Jakarta Bay is one of the most eutrophic embayments in the world with high nutrients and high primary productivity (Damar *et al.*, 2014), as algal blooms by *S. costatum, Pseudonitzschia, Trichodesmium* and *N. scintillans* often occur especially in the dry season. A study of Jakarta Bay from 2001 to 2013 revealed that high DIN concentrations could be observed at river mouths and gradually decreased further into the Bay. Although there was no significant change in eutrophication levels in the Bay during the study period, with relatively stable nutrient pollution levels, these undesired eutrophication effects of hypoxia and algae blooms have been frequently detected in the Bay which can cause serious health threats to humans through seafood consumption (Damar, 2019). Organics accumulation in the sediment of Jakarta Bay leads to hypoxia of the near bottom water of Jakarta Bay, especially those areas along the inner part of the bay (Hayami *et al.*, 2020). In these sites, oxygen levels drop to below 2 mg/L and has led to some ecological problems such as mass mortality of fish.

2.4 Malaysia

Sources of N and P in Malaysia derive from inland from agriculture and chemical fertilisers, organic wastes, untreated sewage, industry and forestry. The major sources of NH_3-N come from animal farming and domestic sewage. In Sabah, sediment, nutrients, litter as plastic bags and marginal settlements without proper sewage and waste treatment facilities all contribute N and P to coastal and marine environments, with industry in Sabah producing heavy metal pollution. River pollution is still a major problem in Malaysia despite substantial efforts to conserve and protect river WQ. Both point and non-point pollution sources are significant contributors to water pollution (Malaysia Ministry of Environment and Water, 2018; Environment Protection Department Sabah website).

Rivers and direct discharge are the means in which pollutants reach the coast and seas. The impacts to coastal waters are similar to other countries, with soil erosion from forestry and industry causing siltation in rivers in Sabah. Furthermore, plastics in Sabah have been observed to smothers corals (EPD & Ministry of Tourism-Sabah website).

The three main parameters that have significant effects on water quality are BOD, SS and Ammoniacal Nitrogen (NH_3-N). Calculation of pollution loads for 2015 excluded food services establishments. The results showed that a total of 525 tons/day pollution load for BOD was generated. Sewage remained the largest BOD load generator with total load of 267 tons/day (51%), followed by piggeries with 213 tons/day (41%), while manufacturing industries contributed 29 tons/day (5%), agro-based industries 10 tons/day (2%) and wet markets 6 tons/day (1%) (WEPA, 2018). The main SS sources come from improper earthworks and land clearing.

2.5 Philippines

The major pollution sources of surface and coastal waters in terms of BOD load are land-based point sources. The types of point sources and contributing proportions are:

- domestic sources 33%
- agriculture livestock 29%
- industry 27% and
- non-point sources 11% (WEPA, 2018).

Similar to most countries, rivers are the main transport mechanisms of pollutants from land to sea.

A total of 122 coastal areas from all around the Philippines were assessed and classified by the DENR – Environmental Management Bureau (EMB) as of the year 2018. Around 46 percent of the coastal waters (56 out of 122) sampled by DENR were classified as Class SB, i.e. sites that are fit for tourism, recreational and fishery use (Phosphate < 1 ml/L and Nitrate as NO_3-N < 20 mg/L) (PEMSEA and DENR, 2019).

Manila Bay is one typical example suffering from pollution. In 2008, the plankton community's distribution was investigated in relation to abiotic environmental variables (salinity, temperature, and DO concentration) and pollution factors, particularly nutrient concentrations. Manila Bay is thought to be highly eutrophicated with high N concentration, particularly ammonium, and excessive N and P loading from surrounding areas (Chang *et al.*, 2009).

In 2018, there was a temporary closure of the tourist resort of Boracay to allow the coastal and marine environment to recover from pollution that caused HABs and deterioration of overall WQ. Although the ecosystem was improving due to the absence of anthropological impacts, unemployment increased, thus, exemplifying the need for a balance between economic gain and ecological sustainability (Questionnaire-Philippines, 2021).

2.6 Republic of Korea

The main sources of N and P in the Republic of Korea (ROK) come from agriculture, industry, and domestic wastewater. Aquaculture contributes nutrients, but is a less serious source. In 2015, daily industrial wastewater discharge amounted to 5,495 tonnes, and was generated from 50,973 units of discharging facilities. The daily amount of animal manure accounted for 118,000 tonnes. Only 1% of the total wastewater volume came from animal manure, but this contributed to 37% of the total pollution loads (MOE, 2016).

The transport pathways of nutrients and their sources are shown in the table below.

Table 3. Sources of N and P and transport pathway to coastal and marine areas of ROK.[4]

Sources	N	P	Transport Pathway to Coastal and Marine Areas
Aquaculture	L	L	Mainly through river run-off
Agriculture	M	M	Mainly through river run-off during rains
Industry	M	M	Mainly controlled by public- and private-owned treatment works systems, but during the heavy rain, incompletely-treated discharges flow into coastal waters via sewers such as through Combined Sewer Overflows (CSOs).
Domestic wastewater	M	M	same as industry
Non-point source	M	M	Mainly through river run-off during early rainfall.

Source: Questionnaire-ROK, 2021.

Four major watersheds cover 89.8% of the national land area, with about 66.4% of pollution loads coming from non-point sources other than industrial and sewage effluent from point sources (MOE, 2021), thus ROK focuses on controlling N and P from non-point sources. Even though most coastal waters are not supposed to have problems with N and P enrichment from point sources due to strict management measures, in some coastal bays and ports, water quality is not good for living organisms.

As N and P introduced to coastal waters are generally used in primary production of phytoplankton, most of the excessive N and P in ROK's coastal waters are diluted into the open sea after playing a role in supporting coastal ecosystem functions. However, in some semi-closed waters such as Masan Bay and Shiwha-Lake, excessive N and P whose amounts exceed those of healthy coastal and bay ecosystems, may cause algal blooms such as red-tides. These areas together with Kwangyang bay, Busan, and Ulsan Special Management Area (SMA), do not have good enough water quality to maintain healthy ecosystems, and suffer from nutrient enrichment due to weak dilution to the outer seas and land-based inputs exceeding the carrying capacity of those waters. Among the five SMAs, the water quality of Shiwha Lake and Masan Bay

[4] More detailed information on N and P and pollution in ROK are available from the National Institute of Environmental Research (NIER) and Korea Marine Environment Management Corporation (KOEM).

were assessed to be moderately contaminated, in the third level, before a total pollution load management system (TPLMS) for Masan Bay was implemented in 2007, and that of Shiwha Lake in 2011.

According to HAB monitoring by National Institute of Fisheries Science (NIFS) since 1972, HABs continued to increase from the 1980s to the 1990s. After most incidences of 109 HAB occurrences were observed in 1998, the number of observations has declined. Most HABs in the 1970s were caused by diatoms. In the 1980s, coastal dinoflagellates, mainly *Cochlodinium polykrikoides* blooms were observed until 1993. A similar tendency of N and P concentrations in coastal waters were observed; the concentration of nutrients in coastal waters was highest in 1980s and declined since the mid-1990s (MOMAF and MOE, 2006). This is a good example of the relationship between HABs and nutrients in ROK.

"Three main HAB species have caused fisheries (and economical) damage. The high density *Karenia mikimotoi* bloom caused shellfish mass mortality in Jinhae Bay in 1981. In the 1990s, *Karenia* sp. blooms occurred around Tongyeong and killed aquaculture fish. Since the largest fisheries damage of KRW 76.6 billion in 1995 (~USD 9.57 million) was caused by *C. polykrikoides* blooms, it has been occurring continuously. This reduction in nutrient concentration is a good explanation for the decrease in HABs. Since 2016, high water temperatures of 30°C or more in summer has been observed with the range and scale of *C. plykrikoide* blooms greatly reduced. *K. mikimotoi* blooms in 2016 occurred around Wando, Jangheung and Goheung and small-scale blooms of *C. polykrikoides* occurred around Yeosu. There were no *C. polykrikoides* blooms in 2017, but *Alexandrium affine* blooms occurred from Yeosu to Tongyeong. There were small-scale blooms of *C. polykrikoides* in 2018 compared to the previous years. These results show that nutrients reduction and high water temperature from climate change affect HAB variation in Korean coastal waters" (Lim *et al.*, 2020).

Analysis of nutrients in North Pacific waters during the period between 1980 and 2010 revealed no drastic changes in phosphate, but an increase in N levels. This has been reported to be the result of the deposition of NO_x from the atmosphere due to the rapid industrialisation of ROK and China (Kim *et al.*, 2011). In addition, the level of nutrients carried by the warm Tsushima Current is about tenfold higher than atmosphere deposition, suggesting that the amount of nutrients contained in Korean waters may be affected by climate change (Kim *et al.*, 2013).

2.7 Singapore

The marine and coastal areas of Singapore are widely used for an array of industries comprising shipping, transportation, petroleum, and petrochemical manufacturing, in addition to non-industrial activities such as residential development and recreational usage. The Pollution Control Department (PCD) of the National Environment Agency (NEA) regularly monitors the water quality of various inland water bodies and coastal areas. In 2014, a real-time continuous water quality monitoring system for the coastal waters of Singapore was commissioned. The monitoring system comprises eight buoy-based stations equipped with sensors to monitor key water quality parameters. Data collected from the eight buoys is transmitted real-time to an Operational Management System (OMS), which processes and manages the data. Furthermore, the OMS incorporates water quality models for the forecasting of water quality, backtracking, and determining coastal areas affected by oil or chemical spill incidents (National Parks Board (Singapore) and PEMSEA, 2019).

In Singapore, the main sources of N and P are shown in the table below. Singapore has a good system to manage pollution sources, thus the sources are all ranked as low.

Table 4. Sources of N and P, transport pathway to coastal and marine areas of Singapore.

Sources	N	P	Transport Pathway to Coastal and Marine Areas
Industry	Low	Low	Waterways out to sea
Others (non-point)	Low	Low	Reservoir and waterways discharge

Source: Questionnaire-Singapore, 2021.

The fate of any N and P discharged from reservoirs or inland waterways are diluted by local seawater. However, development pressures and coastal modifications continue to be the main threat to Singapore's remaining intertidal habitats. Sedimentation and water clarity issues stemming from coastal works, if not mitigated, can threaten marine intertidal biodiversity. Intertidal habitats are also very prone to pollution, especially oil spills when they make landings on the shores. Shipping activities with heavy vessel-traffic in the limited sea space is another factor leading to ship groundings, and increasing the risk of collision-related oil and chemical spills that can increase N and P compounds to the marine environment. There is also the potential impact of invasive alien species that could be brought in to Singapore's coasts from the ballast water of ships berthing there, as well as via cargo since a large volume of shipped goods passes through Singapore. Apart from land reclamation, natural degradation processes such as coastal erosion have also resulted in the reduction of intertidal habitats.

The occurrences of eutrophication of coastal waters in South East Asia have increased dramatically, with the concurrent rise in loading from domestic and industrial effluents, urban and agricultural run-off and reclamation works. Occurrences of HABs in Singapore have been reported (National Parks Board (Singapore) and PEMSEA, 2019). N and P inputs to coastal and marine environments have been increasing incidents of HABs. This is a concern to seawater desalination plant operations, aquaculture, and marine life.

2.8 Thailand

N and P sources and transport pathways in Thailand are shown in the table below.

Table 5. Sources of N and P, transport pathway to coastal and marine areas of Thailand.

Sources	N	P	Transport Pathway to Coastal and Marine Areas
Domestic wastewater	L	L	River
Aquaculture	L	L	River
Industry	M	M	River
Agriculture	M	M	Land to river
Non-point source	M	M	Land to river, river

Source: Questionnaire-Thailand, 2021.

Strong seasonal variations in precipitation and river discharges to the Gulf of Thailand lead to seasonal variations in water quality conditions. The Chaophraya is the largest river contributing about 49% of the Gulf's surface water, with a discharge of 22×10^3 million cubic metres per year. Primary production in the Gulf is recognized to be relatively high, as the result of high nutrient input through rivers and from chemical fertilizers, household sewage and shrimp farms along the coast. The large metropolis of Bangkok contributes urban runoff (Wattayakorn, 2014).

The coastal and marine nutrient (N and P) hotspots are designated according to coastal water quality that exceeds the Marine Water Quality Standard (MWQS) of Thailand (Questionnaire-Thailand, 2021). These areas are located the inner Gulf of Thailand especially at the of river mouth of the Bangpakong, Chaophraya, Tha Chin, Mae Klong, and Bang Thabun Rivers due to observed lower than acceptable standards for the past 20 years (Talue-McManus, 2000; Wattayakorn, 2003; Wattayakorn, 2005).

However, there is a continuing debate among Thai scientists as to whether the Gulf of Thailand is a source or sink for carbon, N and P due to limited knowledge on the biogeochemistry of the Gulf. Many processes are still not well known, in particular the biogeochemical budgets of carbon and nutrients. In any case, WQ monitoring results by PCD and researchers all reveal that the Inner Gulf contains high levels of N and P.

A study by Wattayakorn (2014) observed that DIN concentration in the Inner Gulf was higher in the wet season as compared to the dry season but DIP concentration was lower. DIN/DIP ratio was 16 (Redfield ratio) in the wet season but was lower than 16 in the dry season. This suggests that the limiting nutrient of photosynthesis in the Inner Gulf is DIP in the wet season and shifts to DIN in the dry season.

A high level of nutrients export during the wet season reflects the inputs from agricultural, domestic and industrial wastes. Wattayakorn's research (2014) modelled nutrient flux from the Inner Gulf to the outer Gulf Area. The model showed that the Inner Gulf removed (outflow) DIP at the rate of 0.34 $mmol/m^2/day$ (at the end of the wet season of October 2011) serving as a sink, but then almost balances out in February 2012. On the other hand, modelled DIN values in the Inner Gulf were negative in all sampling seasons, with DIN removal rates of 2.05 and 0.42 $mmol/m^2/day$ in October 2011 and February 2012, respectively, thus serving as a sink for DIN.

The Central Region sees a high volume of untreated wastewater discharged into rivers then flowing into the Gulf of Thailand. Other coastal provinces experience WQ levels that exceed the MWQS as defined by PCD, and shown in the following table and in Chapter 3 on monitoring. Further information on areas where NH3 exceed the WQ Standard of Thailand is available from PCD, but only in Thai language (please refer to Chapter 3).

Table 6. Coastal provinces of Thailand that experienced WQ levels that exceeded national MWQS in 2020.

Province	Areas
Trad	Pak Khlong Bang Yai
Rayong	Na Dan Pier, Ao Prao (Samet Island), Rayong River Mouth, Suchada Beach
Chonburi	Sattahip Port, Jomtien Beach, Naklua Market, Laem Chabang Port, Sriracha (Koh Roy), Bang Saen, Ang Sila, Ao Chonburi
Phetchaburi	Pak Khlong Ban Laem, Chao Samran Beach Puek Tian Beach, Cha Am Beach
Prachuap Khiri Khan	Pranburi River Mouth, Prachuap Bay

Province	Areas
Chumphon	Chumphon River Mouth
Surat Thani	Pak Khlong Tha Khey, Floodgate at the Pal Khlong Rawa
Ranong	Pak Khlong Ranong
Phuket	Patong Beach
Satun	Ban Pakbara Beach

It is common to see N and P in the inner Gulf of Thailand exceeding the MWQS, and eutrophication and red tides often occur especially in Chonburi Province where tourism, aquaculture, and other marine living organisms can all be impacted.

In the Gulf of Thailand, green *Noctiluca spp*. is a main causative red tide species. *Noctiluca* bloom was first reported in 1957 (Charernphol, 1958). Since then, the blooms occurred more frequently in the eastern part of the upper Gulf and studies on seawater discoloration has focused on its impact on fisheries. Although green Noctiluca is harmless, negative impacts of its dense bloom on fisheries can occur when the blooms decay and produce massive slime that can clog fish gills, deplete oxygen in the water, and increase ammonia concentration.

2.9 Viet Nam

The major pressure and threats to Vietnam's marine environment are urban and industrial activities discharging untreated domestic and industrial wastes to the sea in both solid and liquid forms. Organic waste from industrial activities has a significant impact on the marine environment, degrading the quality of fish and other marine organisms, causing toxicity particularly in bays and estuary areas with waste discharge. Pollution of surface waters and surface-borne toxins are also threats to coastal areas (PEMSEA, VASI, MONRE, 2020). The waters of coastal urban areas have been affected by socio-economic development such as seaport and tourism activities, concentrated urbanization, and the operation of industrial clusters. About 70% to 80% of waste in the marine environment are generated from inland sources, specifically from factories, industrial zones, and residential areas (MONRE – Viet Nam, 2019).

Aquaculture activities also significantly increase the amount of waste discharged directly into the sea, mainly fertiliser and artificial feed. With a total area of shrimp farming of over 600,000 hectares, there are nearly 3 million tonnes of solid waste discharged into the environment every year. Solid wastes from aquaculture consists of pond sludge, sediment, and a mixture of uneaten food, faeces, phytoplankton, and colonising bacteria (PEMSEA, VASI, and MONRE 2020). The rate of sediment accumulation in intensive shrimp ponds depends on stocking density and the type of commercial pelleted feeds that are used. At a stocking density of 25 shrimp/m^2, sedimentation is reported to be about 123 tons/crop/ha, whereas it can reach 201 tons/ha/crop for a stocking density of 35 shrimp/m^2. The relationship between sediment accumulation and stocking density shows that in higher stocking density conditions, more feed is required which results in higher volumes of waste (uneaten feed and excreta) being generated and accumulated in ponds and/or discharged to the sea (Nguyen, 2017).

Almost all waste from fishing villages is discharged into the sea without treatment, including cooking coal slag, which is very difficult to collect, leading to marine pollution, and several blocked canals (PEMSEA, VASI, and MONRE, 2020).

Rapid urbanization and industrialization have seriously affected water quality. Unregulated domestic and industrial wastewater discharges into rivers and lakes have impacted the biodiversity of those natural ecosystems. Urban lakes, especially lakes in Hanoi, have been suffering eutrophication (WEPA, 2018). This has become quite common, causing algae blooms (mostly *Microcystis* spp.), reducing DO and leading to a mass death of fish in the city's West Lake (Ta and Lap, 2020).

Despite these threats, WEPA (2018) states that in general, the quality of coastal water in Viet Nam is still quite good with most of the typical parameters of seawater quality lying within the permitted limits of *QCVN 10-MT: 2015/BTNMT* (National Technical Regulation on Marine Water Quality – in Vietnamese only). The Risk Quotient (RQ) is calculated according to *Circular No. 26/2016/TT-BTNMT*, and classified as follows:

- RQ ≤ 1: Low pollution risk
- 1 < RQ ≤ 1.25: Average pollution risk
- 1.25 < RQ ≤ 1.5: High pollution risk
- RQ> 1.5: Very high pollution risk level.

Calculation results of the RQ during the period 2015-2018 show relatively low pollution levels and low risk (RQ<1) in coastal waters.

- Northern region: 85.5%
- Central region: 97.5%
- Southern region: 75%.

In particular, the coastal water monitoring results in the period 2015-2018 as stated in PEMSEA, VASI, and MONRE (2020) show the following results:

- Northern region: The northern coastal waters have low level of risk from pollution. However, in some areas with strong aquaculture development, such as in Hai Phong, Nam Dinh, Thanh Hoa, there have been some records of N-NH_4^+ and TSS content exceeding QCVN for aquaculture and conservation areas. In 2018 found pollutant discharge from tourist in Quang Ninh province TN 792.63 ton/year and TP 281.82 ton/year.

- Central region: Coastal waters in the Central region have low level of risk from pollution. However, there are localized pollution problems in aquaculture and port areas. There are also localized problems in some sea areas. Sometimes during summer, spilled oil can be observed on seawater surface, causing impacts to the quality of the marine environment. This could be due to traffic incidents at sea or from unknown sources.
- Southern region: Coastal waters in the southern region has a lower risk of pollution than the two regions above. The parameters exceeding the QCVN with quite high frequency are mainly TSS, Fe (in the rainy season), NH_4^+, NO_2-N, NO_3-N, and coliform (only localized), making the RQs in the South to increase. The coastal environment in the south of Viet Nam is often influenced strongly by riverine flow, with some areas affected locally by aquaculture activities.

The coastal waters in Southern Central and Southeast Viet Nam have encountered eutrophication for some time with NO_3^- and COD being the main factors (Pham and Vinh, 2000). Some coastal areas have been polluted locally, specifically by NH_4^+, NO_2, NO_3-, coliform and TSS, exceeding the National Technical Regulation due to farming activities in coastal and estuarine areas.

In 2016, an usually large fish kill occurred in four coastal provinces in Central Viet Nam (Ha Tinh, Quang Binh, Quang Tri and Thua Thien Hue), and several hot spots of environmental pollution broke out in many provinces and cities nationwide. Tho Quang (Da Nang city) has become a hotspot of marine pollution in recent years (MONRE – Viet Nam, 2019).

In the coastal areas in the provinces of Khanh Hoa, Ninh Thuan, and Binh Thuan, red tide occurred with severe impacts on biological and environmental resources such as an outbreak of *Noctiluca scintillans* in Van Phong Bay (Khanh Hoa) resulting in losses for lobster farmers. The outbreak of *Phaecocystis globosa* along the coastal areas in Phan Ri Bay destroyed 90% of aquatic species in tidal reefs and caused a loss of over 10 billion Vietnamese dong (~$650,000 US) (Liu, X, 2011).

Research on coastal toxic algae and red tide in Viet Nam shows that some microalgae species tend to grow seasonally every year, especially from March to September, causing damage to aquaculture in coastal waters. (MONRE – Viet Nam, 2019). The cause was due to rapid development of tourism, urbanisation, agriculture, and industry. At the same time, the production of aquatic seeds and cage culture of lobster and grouper also release significant volumes of nutrients, creating favourable conditions for algal growth (WEPA, 2018).

2.10 Regional

Rivers are a central link in the chain of nutrient transfer from watersheds to coastal and marine systems. Nutrient inputs to watersheds include natural (biological N2-fixation, weathering of rock releasing phosphate) as well as many anthropogenic sources. At the global scale, anthropogenic N inputs to watersheds are now greater than natural inputs (Galloway *et al.* 2004).

The Yellow Sea has been encountering increased incidents of HABs and jellyfish blooms. The southern part of the Sea has seen increased concentrations of DIN and HAB blooms (S. Uye, pers. comm.). Eutrophication in other parts of the Sea also occur, as was seen in 2008 when a 13,000km^2 slick of algae was cleared from the area that was to host the Olympic Games' sailing events. It was estimated that the unusually hot and sunny weather boosted the fertilising effect of N and P on the algae, which is common in coastal areas fed by rivers that collect run-off from fertilised agricultural land, and from industrialized or urban areas (Marris, 2008).

The South China Sea is considered to be moderately productive, but has the "highest" risk of eutrophication (Seitzinger and Mayorga, 2016). In the late 1970s, land use in the fertile river delta north of Hong Kong was primarily agriculture. Since then, the Pearl River Delta has been transformed from farmland into a large megapolis and resulted in dissolved N and P inputs via the Pearl River Delta increasing by a factor of 2 to 5 over the past four decades. N and P inputs are largely due to increases in urban waste discharges and nutrients released from aquaculture operations (Yin and Harrison, 2008).

Overall, the impact of anthropogenic nutrient loading appears to be limited to the coastal margins of the South China Sea (Sun, 2017) with hotspots of seasonal hypoxia and toxic algal events observed in the vicinity of major river deltas with substantial urban development. The areas with the most severe eutrophication are associated with estuaries of the main rivers. One of the most severely impacted areas is the lower Pearl River estuary which has experienced annual summer hypoxia in bottom waters. Oxygen depletion in these bottom waters has occurred every summer for at least the last 25 years (Qian *et al.*, 2018).

The East China Sea LME is considered to be a highly productive system and is in the "highest" risk category for eutrophication (Seitzinger and Mayorga, 2016). The Yangtze River accounts for more than 90% of nutrient inputs into this Sea (Yuan *et al.*, 2007; Tong *et al.*, 2015).

In summary, sources of N and P in the regions come mainly from land-based sources such as agriculture (chemical fertilisers, pesticides, herbicides), domestic waste, and industry. Unsustainable aquaculture is a contributing source in some countries. Rivers are the main transport pathways of nutrients.The sinks for N and P are coastal and marine areas where they are taken up by aquatic organisms, deposited into sediments or remain floating in the water column. The impacts of eutrophication across the region include HABs, health hazards to aquatic organisms and human beings, fish and shellfish death, and loss of economic revenue and livelihoods. Hotspots and areas observed to suffer from high concentrations of N and P can be found in river mouths, bays, and coastal areas consisting of large cities and industrial areas.

3. Management and Governance Measures

3.1 National Legislation

Each country has numerous laws, acts, decrees and action plans governing overall environment and water resources protection. Countries have many laws that specifically address domestic wastewater treatment and management, industrial and solid waste management, and pollution emmissions and control. There are also laws governing agricultural paractices that deal with chemical fertiliser use and management. All of the previously mentioned legislation types address managing nutrients and wastes in upstream areas before they flow to the nutrient sinks in the coastal areas.

There is also legislation relevant to how aquaculture wastes should be treated before discharge both from ponds on land and in mariculture areas in the coastal areas and offshore. Furthermore, laws governing clean water for human usage, recreational use, and domestic treatment is common in all countries to minimise pollution being transported to downstream and coastal areas.

Countries update their laws to meet environmental, economic, and societal changes and to be more stringent and effective in managing nutrients and pollution. However, there remain some gaps in enforcement, compliance, and self-regulation, the last two particularly in the agriculture and industrial sectors (see Chapter 4).

Action plans for specific areas such as bays and special management areas make it possible to implement specific and targetted nutrients and pollution management actions for the specified water body. These governance measures in some countries allow wide stakeholder participation in developing the management plans and reaching common consensus to benefit the aquatic resource users while also complying with national laws.

The many existing legislation are listed in more detail in Annex 3. The list is not exhaustive, and it is evident that each country is aware of and taking steps to better manage nutrients and prevent pollution, with some countries listing specific targets to control pollutants.

3.2 Regional Action Plans and Programmes

Strategic Action Plans/Programmes (SAP) have been developed under GEF Large Marine Ecosystem Projects for Yellow Sea, South China Sea, Arafura and Timor Seas Region, and Sulu-Celebes Sea. SAPs are endorsed by National Focal Ministries of each project. All have management actions addressing elements of land- and sea-based pollution

.

Table 7. LME Projects in the East Asian Seas region.

Large Marine Ecosystem	Participating Countries
Yellow Sea SAP	China, ROK
South China Sea SAP	Cambodia, China, Indonesia, Malaysia, Philippines, Thailand, Vietnam
Arafura and Timor Seas Region	Indonesia, Papua New Guinea, Timor Leste
Sulu-Celebes Sea	Indonesia, Malaysia, Philippines

3.3 Global Conventions

COBSEA countries are also signatories to global environment- and pollution- related conventions including:

1) MARPOL - The International Convention for the Prevention of Pollution from Ships. MARPOL is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. Annex IV addresses sewage discharges from ship.
2) London Convention and London Protocol - The "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972". One of the first global conventions to protect the marine environment from human activities and has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter.
3) The Ballast Water Management Convention or BWM Convention (full name International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004) is a treaty adopted by the International Maritime Organization (IMO) in order to help prevent the spread of potentially harmful aquatic organisms and pathogens in ships' ballast water.
4) The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is a multi-lateral convention that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries.

5) United Nations Convention on the Law of the Sea (UNCLOS) - an international treaty established to define coastal and maritime boundaries, to regulate seabed exploration not within territorial claims, and to distribute revenue from regulated exploration. There are articles contained therein that list measures to prevent, reduce and control pollution of the marine environment.
6) Convention on Biological Diversity (CBD) - known informally as the Biodiversity Convention, it is a multilateral treaty with three main goals: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of benefits arising from genetic resources. There are thematic programmes on Island and Marine and Coastal Biodiversity that address pollution impacts to these ecosystems.

Table 8. COBSEA countries that are signatory to global conventions.

Convention	Signatories
MARPOL	Cambodia, China, Indonesia, Malaysia, Philippines, Republic of Korea, Singapore Viet Nam
London Convention	China, Republic of Korea, Philippines
BWM Convention	China, Indonesia, Malaysia, Philippines, Republic of Korea, Singapore
Basel Convention	Cambodia, China, Indonesia, Malaysia, Philippines, Republic of Korea, Singapore, Viet Nam
UNCLOS	China, Indonesia, Malaysia, Philippines, Republic of Korea, Singapore, Thailand, Viet Nam
CBD	Cambodia, China, Indonesia, Malaysia, Philippines, Republic of Korea, Singapore, Thailand, Viet Nam

The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) is another intergovernmental mechanism to address land-based pollution. The GPA was adopted by 108 Governments, and the European Commission at an intergovernmental conference in Washington, D.C., in 1995. The parties set a common goal for a sustained and effective action to deal with all land-based impacts on the marine environment, specifically those resulting from sewage, persistent organic pollutants, radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment mobilisation, litter, and physical alteration and destruction of habitats. Since 2012, nutrient management, marine litter, and wastewater have been highlighted as priority areas to address.

3.4 Pollution Reduction Targets and Management Measures

Research, monitoring, and assessments are carried out across the region to see if nutrient and pollution reduction targets and laws are being met. The section below describes pollution reduction targets (where available) and management measures that illustrate the various efforts undertaken in each country.

3.4.1 Cambodia

The National Committee for Management and Development (NCMD) of Cambodian Coastal Areas which is directly subordinate to the Royal Government, is in charge of managing and developing the coastal areas of the country in a sustainable and responsible manner. The NCMD is chaired by the Ministry of Land Management, Urban Planning and Construction, with the Ministry of Environment and Ministry of Tourism as the vice chairs.

Cambodia's "National Strategic Development Plan 2019-2023" states that the Ministry of Environment and National Council for Sustainable Development agree to monitor and inspect pollution sources through:

- Enforcing legal regulations related to environmental protection at factories, enterprises, companies and investment projects throughout the country.
- Promoting the implementation of automatically regulating and reporting system for critical pollution sources and install an automatic tool for monitoring waste release.
- Promoting the implementation of the database of toxic substances released to the environment.

3.4.2 People's Republic of China

China has very specific pollution reduction targets. The 13th Five-Year Plan (2016-2020) for emissions reduction aims for total COD, ammonia nitrogen, sulphur dioxide and NOx emissions to be under 2.07 million tons, 15.8 million tons and 15.74 million tons, respectively, i.e. reductions of 10%, 10%, 15% and 15%, respectively from 2015 levels.

The 14th and 15th emission reduction plans are being developed. They do not set specific targets for nutrient loadings because it is very difficult to monitor and assess all the sources. However, there are seawater quality criteria that sets nutrient concentration limits. There are not yet specific timelines for the reduction of specific amount of nutrients in coastal waters, but require that all the local governments improve seawater quality by incremental steps (NMEMC, pers comm.).

There is also a comprehensive sewage discharge standard the follows the “National Standards of the People's Republic of China (GB 8978-1996).”

Aside from the many laws addressing water quality and pollution, China engages in many measures from local to provincial to national levels to address nutrients pollution. Some examples are given below.

In 2015, the Ministry of Agriculture issued the “Action Plan of Zero Growth in Chemical Fertiliser and Pesticide Use by 2020” and in 2017 the “Action Plan for Replacement of Chemical Fertiliser by Organic Fertiliser for Fruits, Vegetables and Tea,” in order to promote circular resources use for cost reduction and efficiency enhancement, and encouraged and guided farmers to apply farmyard manure and organic fertilisers to reduce nutrient loadings into groundwater and other water bodies.

The “Action Plan to Combat Pollution in the Bohai Sea” released in 2018, saw over 18,000 sewage outlets to the Bohai Sea investigated including checking permit qualifications. Illegally established mariculture sites and sites that didn’t adhere to management criteria were closed down. All coastal cities bordering Bohai Sea must create a “marine sanitation” system to treat wastes before discharge. The Action Plan has set a target of cleaning 70% of the seven major rivers including Bohai, and achieving 93% of rivers be suitable for drinking water use (MEE, 2018, 2019).

The “Water Pollution Prevention and Control Action Plan” and the “Coastal Water Pollution Prevention and Control Plan” seek to reduce land-based pollution, control sea-based pollution sources, and implement a monitoring system to track implementation of these measures in coastal cities. In implementing these plans, at the end of 2019, for land-based pollution, 602 illegal and improper established sewage outlets were cleaned and 88,000 discharge permits issued in 11 coastal provinces and autonomous regions.

The Hangzhou Bay Pollution Control Plan seeks to improve surface water quality, control N and P loads of rivers flowing into the bay, decrease eutrophication and reduce DIN and DIP concentrations, control TN emissions in sewage treatment plants and rivers entering the marine environment, and control agriculture and livestock breeding for total discharge control. Other possible pollutant sources such as aquaculture practices along the bay must meet specific management criteria. The plan also aims to improve the early warning and response system for water pollution accidents (Zhejiang Province, 2020).

China's 2019 Marine Bulletin (MEE, 2020) emphasises the use of remote sensing for various coastal management actions including monitoring chl-a concentration to take preventive actions before red tides will occur, monitor water quality to restore fisheries resources and ensure good water quality for sustainable marine ranches to produce high quality products, and also to monitor coastline changes by natural or anthropogenic factors.

3.4.3 Indonesia

Indonesia has a Water Quality Index system for water quality of river and marine systems ranging from 1 to 100 with 1 being poor. The index is part of the environmental indexing system covering air quality, water quality and soil/land quality. The index is determined on WQ meeting standards for physical and chemical (NH_4^+, NO_3^-, PO_4^{3-}) parameters, dissolved metals, organism concentration, and radioactive materials as stipulated by Indonesia's Ministry of Environment Decree No. 51/2004, which was recently replaced by Indonesia's Government Regulation No. 22/2021 on the Administration of Environmental Protection and Management. Specific for water quality, the target is as follows (RPJMN 2020-2024) (Directorate of Water Pollution Control/PPA-MOEF):

Objective	**Indicator**	**Targets**				
		2020	**2021**	**2022**	**2023**	**2024**
Water quality improved	Water quality Index	55.1	55.2	55.3	55.4	55.5

Some target indicators are as follows, stated by the Directorate of Water Pollution Control (PPA-MOEF):

- Number of locations of river and lake water quality monitored manually.
- Number of locations of river water quality monitoring stations operating continuously.
- Number of businesses and/or activities that meet wastewater quality standards.
- Number of Water Pollution Control Facilities in Citarum Watershed.
- Number of Wastewater Treatment Facilities in priority watersheds.

The Directorate of Coastal and Marine Pollution and Degradation Control (PPKPL-MOEF) engages in numerous measures to manage pollution in Indonesia's coastal and marine environments. Actions are related to research and governance.

- An inventory of pollutant sources of coastal and marine areas and preparation of seawater quality index.
- Additional communal wastewater treatment facilities.
- Improving NUE including capacity-building and knowledge improvement.
- Expanding research on nutrient cycling and management at global, regional and national levels to improve understanding of the complexity of global nutrient cycles and the potential for recycling organic nutrient sources. Research to focus on the agricultural sector and the sectors reliant on use of detergents.
- Conduct region-specific economic valuations on the impacts of nutrient pollution and the benefits of sustainable nutrient management (including nutrient recycling).
- Nutrient pollution reduction at point sources to be implemented through a mechanism on monitoring obligation by industries that produce N and P stipulated as a mandatory action in their production license and permit.
- Improving waste disposal licensing into the sea.
- Participation in GPNM – knowledge exchange, using the Global Nutrient Management Toolbox, streamlining it to UNEP Regional Seas initiatives in the region.
- Improving collaboration across different national sectors including the private sector and other countries to implement nutrient recovery measures.

The Citarum Watershed is a particularly high source of land-based pollution and Directorate of PPA-MOEF has a specific programme to reduce pollution in this area. Actions include:

- Restoring the Citarum River to be an eco-riparian area.
- Producing the livestock digest to better understand the agricultural practices and their impacts in the watershed.
- Installing wastewater treatment for the tofu industry, one of the major industries in the area.
- Installing communal domestic wastewater treatment facility.
- Water sampling training for local communities as a citizen science initiative.

- Construction, operation and maintenance of Automatic, Continuous and Online Water Quality Monitoring Tools.
- Regular monitoring, regular inspection and law enforcement are conducted in the watershed (Questionnaire – Indonesia, 2021; COBSEA Focal Point for Indonesia).

Indonesia has some good examples of wastewater management for sustainable tourism implementation in Bali through the wastewater treatment facility in Nusa Dua in Bali. A complex of 10 big hotels with centralized wastewater treatment reuses the treated wastewater to water the plants and gardens in the hotel complex. The wastewater treatment lagoon is also an eco-park with opportunities for bird watching and recreational fishing (PEMSEA and MoEF, 2019).

3.4.4 Malaysia

The 10th Malaysian Plan 2011–2015 (Malaysia, 2010) set a target for WQ improvement, and included efforts to tackle pollution in river waters, the country's main water source, by addressing the major pollution sources. Measures mentioned in the plan include:

- Strengthen the enforcement of effluent standards of sewage and industries in line with Environmental Quality (Sewage and Industrial Effluents) Regulations.
- Assess total maximum daily loads for both point and non-point sources.
- Revise the Water Quality Index by incorporating other variables for more accurate river water classification.
- Develop the National Marine Water Quality Index.

Malaysia has set marine WQ standards for different classes/areas of water bodies, i.e. marine habitats, fisheries, industrial and coastal settlements, estuaries, recreation. Assessment on pollution load is mainly focused on three main parameters that show high impact on the water body: BOD, SS and Ammoniacal Nitrogen (NH_3-N).

National Water Quality Standards for Malaysia (NWQS) are applied to surface waters and sets out standard values for 72 parameters in six water use classes. The goal is not to meet the standards of a particular water class in all surface waters, but to improve water quality gradually in order to meet the standards of a water class higher than the current class.

Table 9. Water quality classes in Malaysia (WEPA, 2018).

Class	Uses
I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
IIB	Recreational use with body contact.
III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
IV	Irrigation
V	None of the above

Malaysia expanded sewerage coverage from 25% in 1993 to about 70% in 2015, constructed sludge treatment facilities (for septage management or for those not connected to the sewerage system), increased the number of sewage treatment plants while upgrading the existing plants.

The Eleventh Malaysia Plan 2016–2020 (Malaysia, 2015) addresses the improvement of water quality including:

- Raising the financial sustainability of the water services industry by strengthening the tariff system and implementing joint billing for water and sewerage;
- Expanding the network and treatment plant capacities through infrastructure investment and use of efficient technology, through developing new treatment plants, increasing clean and treated water coverage and expanding connected water and sewerage services in rural areas;
- Increasing the efficiency and productivity of water and sewerage services through implementation of the Non- Revenue Water Reduction Program and by rationalizing and upgrading sewage treatment plants; and
- Strengthening the regulatory framework of the water services industry with the National Sewerage Master Plan, a water demand management master plan and promoting a waste-to- wealth initiative (WEPA, 2018).

3.4.5 Philippines

The Focal Point appointed experts in the Philippines provided information on measures the country is taking to manage pollution that is contained in this section. Targets for nutrient reduction have not yet been determined, but in the "General Effluent Standards," industries are required to have treatment technologies to reduce the levels of identified pollutants in their wastewater to an amount less than the specific effluent standard. The standards vary per water body classification to which an industry is discharging its treated wastewater.

Monitoring of water bodies as to levels of pollutants and characteristics, including nutrients such as Nitrate as Nitrogen and Total Reactive Phosphate as Phosphorus, provides data on the state of the water body and whether the mitigating measures implemented to rehabilitate or protect it are effective or not. The general goal of the classification scheme is to prevent the water body from further deteriorating into a lower classification or elevate its classification to a higher one through institutional mechanisms and programs implemented by the DENR through the EMB.

Industrial effluents are regulated through the General Effluent Standards in which the industry is required to secure a Discharge Permit and pay the corresponding fees to EMB prior to discharging. They are also required to submit quarterly Self-Monitoring Reports which contain compliance status and updates as well as other data on the applicable environmental regulations to an industry/ company, including that for the Philippine Clean Water Act.

Certain policies of the DENR with other government agencies such as the Department of Agriculture allow discharge of wastewaters to land for agricultural purposes. Upon acquisition of the required permit/certification, industries such as sugar mills are practicing this with the goal of using the N and P content of the wastewater to supplement nutrient requirements of their agricultural lands.

In the case of domestic wastewater, the water concessionaires in Metro Manila for example, are now aggressively pursuing compliance to the concession agreements with them in terms of connecting households in the area into centralized water treatment facilities to reduce loading into water bodies such as Manila Bay and its tributaries. A water treatment facility was also operationalized near the Manila Bay area in Manila to address the domestic discharges contributing to pollution in Manila Bay.

As Boracay is a significant source of tourism income for the country, in 2018 the DENR through EMB launched an extensive investigation, inspection, and enforcement activity to facilitate the coastal and environmental rehabilitation process. The activity discovered that effluent outfalls were buried beneath the coastal area and were found to be discharging only a few meters offshore in some areas in the island. EMB proceeded to more stringently enforce relevant laws and regulations on environmental management and pollution control. This also led to the establishment of the island's carrying capacity and limits on the number of tourists that can visit the island per day. At present, water quality is still closely being monitored in the island in an effort to protect the environment and prevent further damage to the coastal and marine ecosystems.

There are many research projects addressing the assessment of nutrient pollution. These touch upon the topics of:

1) Physical-chemical properties and metal concentrations in leachate from selected open dumpsites by EMB Central Office.
2) Estimation of nutrient load from aquaculture in Manila Bay and dissolved nutrients in the South China Sea carried out by the National Fisheries Research and Development Institute.
3) Nutrient load estimation for Manila Bay using Population Data implemented by the Marine Science Institute, University of the Philippines.
4) Using stable isotopes to assess pollution loading from various sources in the Pampanga River System to Manila Bay implemented by the Department of Agriculture – Bureau of Soils and Water Management.
5) Post treatment of food processing wastewater effluent to reduce nutrients by Philippine Council for Industry, Energy and Emerging Technology Research and Development.
6) Assessing nutrient dynamics of inorganic and organic rice farming.
7) Recycling animal wastes into liquid fertiliser and methane capture via fermentation.

Non-profit organisations also engage in research, such as the study by Marine Conservation Philippines on sources and levels of sedimentation and nutrient pollution along the southeast coast of Negros Oriental (Questionnaire – Philippines, 2021).

3.4.6 Republic of Korea

The Focal Point appointed expert from ROK provided information on measures the country is taking to manage pollution that is contained in this section. River water quality is based on the water quality criteria for the living environment according to the Framework Act on Environmental Policy and Water Environment Conservation Act to regulate setting-up water quality standards based on the watershed size without the declared targets of load reduction in terms of N and P. On the other hand, when a watershed is designated by the Acts on Water Management and Resident's Support such as in the Nakdonggang, Han Geum and Yeongsang River Basins regulating

TPLMS, each watershed decides its own water quality targets and load reduction levels for the control of P and BOD.

The three largest riverine systems of Geum, Yeongsang, and Nakdonggang, cover many provincial and municipal jurisdictions, and have set water quality targets for their own P and BOD concentrations. The Ministry of Environment is responsible to announce water quality targets to the public and cooperatively discuss the targets of jurisdiction boundaries (boundary-targets) with local governments.

Five Master plans (Provincial Level plans) of TPLMS (from 2016 through 2020) in Nakdonggang River including 41 Unit-watersheds was approved by MOE after long negotiation with five metropolitan cities and provinces such as Busan Metropolitan City, Daegu Metropolitan City, Gyeongsangnam-do, Gyeongsangbuk-do, and Gangwon-do. Seven boundary-targets were set. Compared with the 2nd set of five Master Plans, the overall water quality target of Nakdonggang River watershed in terms of BOD was set at 1.8 ppm (the previous 2.0 mg/L), and that of P was determined to be 0.057 mg/L (formerly 0.075 mg/L). According to the 3rd Master Plans, 41 Implementation Plans had been established considering the 7 boundary-targets by relevant municipalities (Questionnaire-ROK, 2021).

The targets for effluents discharged from industrial and wastewater treatment plants are managed well within 51 parameters and are set under the Water Environment Conservation Act and the Sewerage Act. Moreover, ROK has been continuing to strengthen the effluent management from point sources by adopting new parameters or, upgrading the existing standards to reduce the amount of N and P effluents.

The ROK expert also shared information that targets for P reduction are only applied to the TPLMS for five SMAs coastal areas under the Marine Environment Management Act (MEMA). Before setting the target, MOMAF (now Ministry of Oceans and Fisheries) has to designate the polluted areas according to the MEMA, then all stakeholders discuss the implementation procedure of the TPLMS. MOF also prepares technical guidelines for each SMA’s TPLMS based on the best available knowledge and uniqueness of each SMA. Finally, the 5-year, P target concentration is set by agreement among stakeholders. Province governments establish the entire P reduction target as pollution loads in the Master Plan of TPLMS, and relevant municipalities allocate reduction targets as load.

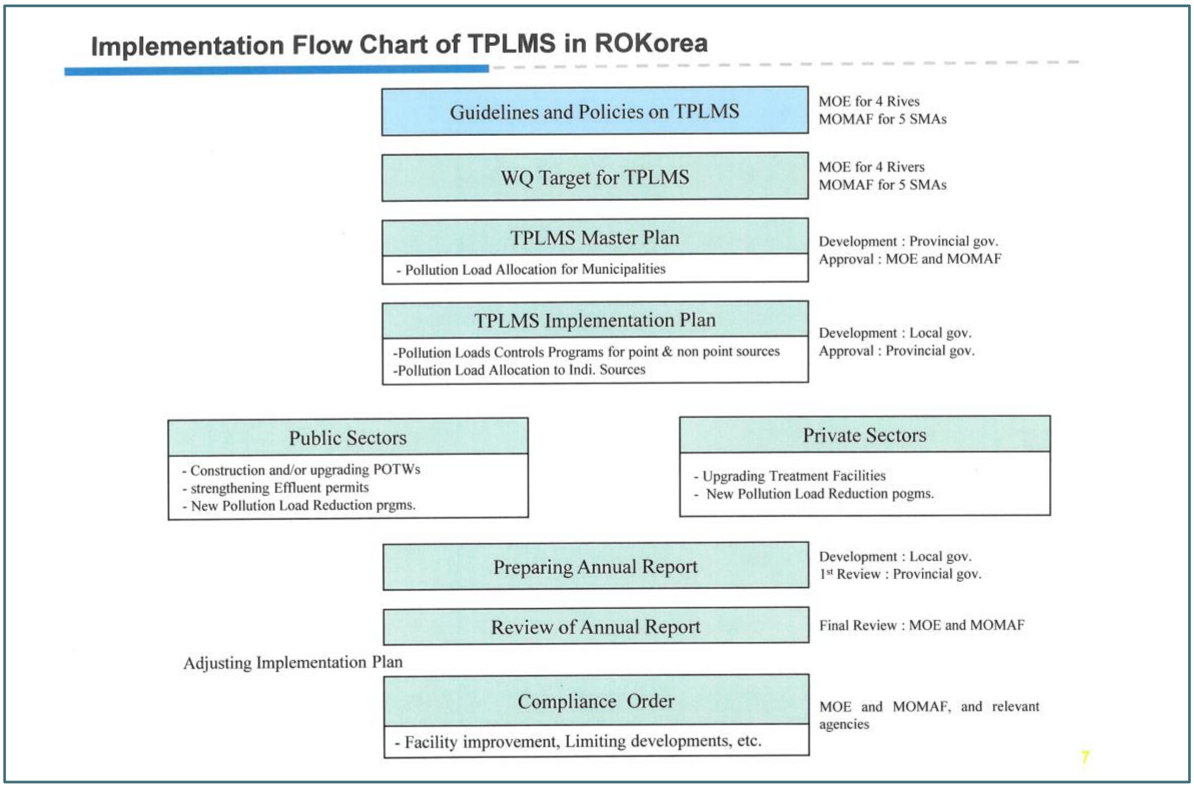

Figure 1. The TPLMS process (Questionnaire – ROK, 2021).

The governance mechanism for coastal TPLMS includes wide stakeholder consultation giving an opportunity for national and regional governments, municipalities, NGOs, local communities, and the military to voice their opinions.

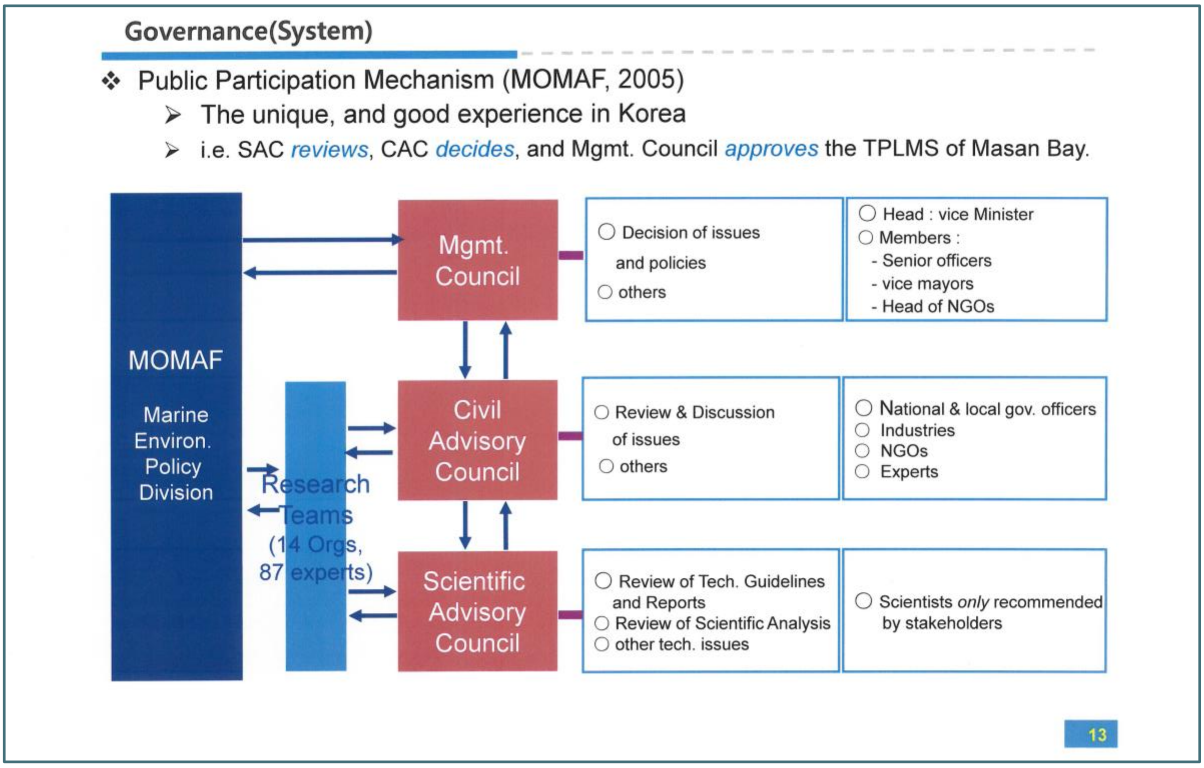

Figure 2. Stakeholder roles for pollution management in ROK (Questionnaire – ROK, 2021).

To protect the marine environment from land-based sources of pollution, the Korean government established an inter-department strategy, called the Basic Plan for Marine Environment Conservation, and began to systematically control contaminants originating from land at their source (MLTM *et al.*, 2011). As a result, the capacity of sewage treatment facilities has steadily increased, and although the values of all indicators including BOD, COD, SS, TN, and TP have risen, the efficiency of eliminating the contaminants has also improved. The area of the country where sewage treatment is available has also steadily grown, from 75.8% of the nation in 2002 to 90.9% in 2011. The wastewater treatment capacity has also improved, with tertiary treatment capacity from 1,929,000 tonnes a day in 2002 to 13,795,000 tonnes a day in 2011 (MOF and PEMSEA, 2019).

Sewage production has not changed significantly since 2005 (Ministry of Environment, 2011). In 2006, the government established a series of marine waste reduction program. As a result, the amount of dredged materials, sewage sludge, fish waste, and natural organic matter dumped at sea was reduced by 10% in 2011 compared with 2008 levels. Starting in 2016, dumping sewage sludge at sea is banned (MLTM, 2012) according to Ministry of Environment's 2015 policy direction.

A large portion of the budget for marine environment management to reduce land-based sources – around 82% of the total budget (USD10.9 billion) of the Fourth Plan (2011-2020). Most of the budget for reducing land-based pollution was invested in the installation of the sewerage system and wastewater treatment plants.

The most successful factor in TPLMSs for Masan Bay and Shiwha Lake was the public participation in environmental decision making and communication between the science-policy interface. Thirty-two public hearings were held for TPLMS planning with consistent participation of local stakeholders and now five Community Advisory Councils (CACs) are linked together and have set up the SMA Network to share experience and knowledge (Questionnaire – ROK, 2021).

3.4.7 Singapore

Singapore has set WQ targets particularly in recreational beaches, where the 95th percentile Enterococcus counts should be less than or equal to 200 counts per 100 millilitres of water. Only beaches classified as 'Good' and above will be considered suitable for primary contact activities.

Land use zoning (locate pollutive land use outside reservoir catchment areas) and pollution control requirements are employed to reduce nutrient load by reservoir discharge.

The Prevention of Pollution of the Sea Act, Revised Edition 1999 states that persons throwing pollutants into the country's waters can be fined up to SGD20,000 (~15,000 current USD equivalent) and/or a prison term of up to six months. Under the Water Governance Framework, the Public Utilities Board (PUB) is the comprehensive water authority, integrates sewerage & drainage departments, manages reservoirs, water works, rivers, drainage system, water reclamation plants, and sewerage system to optimise use of Singapore's water resources. Water and sewage tariffs are issued at household and industrial levels.

Singapore has extensive wastewater management facilities and multipronged approaches to reduce the amount of nutrients, namely implementation of stringent catchment management policy, integrated catchment water quality management (ICWQM) Programme, and ABC Waters Programme. Following the continuous effort to implement these nutrient control measures, the median phosphate levels in the local catchment have generally dropped over the years, i.e. from the range of 0.016-0.075 mg/L in 2001 to 0.003-0.034 mg/L in 2015 (Goh and Sim, 2016).

Since 2005, PUB has embarked on an ICWQM Programme to manage water quality of urbanised catchment. The main aim of this programme is to ensure that water quality in the reservoir will be good for potable water production and safe for recreational use. The ICWQM Programme is made up of four key strategies namely source control, mitigation measures, engaging the Public, Private and People (3P) Sectors, and use of technology. PUB is working closely with other public agencies to phase out pollutive industries within water catchments by progressively relocating the pollutive industries to new and modern industrial complexes with proper facilities or out of water catchment and implementing anti-pollution measures as an interim measure before relocation (Goh and Sim, 2016).

PUB has also set up dedicated catchment surveillance teams to complement NEA by carrying out intensive surveillance to look out for illegal discharge, improper disposal of liquid and solid waste, and improper storage of waste materials. PUB also employs educational approached to reduce P loading from detergents, i.e. distributing brochures and posters to educate residents and various stakeholders (e.g. industrial site owners, food cleaning supervisors, petrol kiosk operators, bin centre operators, and construction site workers) about pollution from washing activities and the availability of green-labelled detergents, and posting on webpages to encourage stakeholders to adopt good practices to safeguard water resources. The OMS also helps to determine if WQ is affected. More details on monitoring data and OMS are mentioned under Singapore's monitoring programmes in Chapter 3).

Dredging has been carried out in the main body of Jurong Lake in 2008-2009 and desilting was done in Jurong Lake catchment (Jurong Canal and Sg Lanchar) in 2009-2011 which improved the phosphorus and chlorophyll-a levels in Jurong Lake significantly. Planting macrophytes in reservoirs is another way to absorb N and P.

Increasing aeration for reservoir mixing, eliminates temperature differences between top and bottom waters, and inhibits P release from sediments, hence diminished this internal nutrient loading.

PUB is studying the application of advanced bioretention system as an effective method to capture P and transform N in the runoff. Advanced bioretention system is filled with advanced filtration media which can irreversibly binds up P and is installed with an advanced drainage outlet which gives enough time for biological processes to remove N. If positive results are obtained from the study, this technology can potentially be applied at catchments with relatively higher nutrient levels such as the agricultural areas at Kranji Reservoir catchment (Goh and Sim, 2016).

3.4.8 Thailand

Thailand has not set specific targets for N and P pollution reduction, but has programmes and action plans to improve water quality. For example, to meet SDG 14.1, Thailand implements research on waste reduction and management in coastal provinces, monitoring WQ, and coastal clean-up activities. The determination of pollutant baseline data looks at coastal seawater concentration of NO_2, NO_3^-, PO_4^+, and chl-a. The Department of Marine and Coastal Resources has established more than 166 research stations along the coasts of the Gulf of Thailand and Andaman Sea for data collection on WQ and eutrophication and projects and activities to monitor coastal and marine debris (ESCAP, 2019; Thailand CSD, 2017).

Based on "The Enhancement and Conservation of National Environmental Quality act, B.E. 2535 (1992)", there are laws related to nutrient management and prevention and reduction of nutrient leakage/pollution as follows:

1) For the purpose of environmental quality enhancement and conservation, there are environmental quality standards:
    a. Water quality standards for river, canal, swamp, marsh, lake, reservoir, and other public inland water sources according to their use classification on each river basin or water catchment
    b. Water Quality Standards for coastal and estuarine water areas.
2) Effluent Standard for the control of wastewater discharge from point sources into the environment - coastal aquaculture, brackish water aquaculture, freshwater aquaculture, pig farm, buildings, allocated land, community water treatment system, factory and Industrial areas, and fishing pier.

Water quality data and information are available to the public online from:

- www.pcd.go.th/watertype/แหล่งน้ำทะเล/ (Coastal Water Quality)
- http://marine.pcd.go.th/main (Coastal Water Quality)
- http://iwis.pcd.go.th/ (Inland Water Quality)

To control and manage water quality problems, existing regulations can be grouped into three actions as follows:

1) Applying Environmental Impact Assessment to determine the impacts and mitigation plans for development projects such as dams with storage volumes of 100 million m^3 or more, irrigation projects of 12,800 ha or more, hotels or resorts of 80 rooms or more, thermal power plants with capacities of 10 MW or more, mining projects of all scales.
2) Establishing and applying effluent standards such as industrial effluent standards, domestic effluent standards, and effluent standards for pig farms and aquaculture.
3) Setting the ambient water quality standards based on the state of water quality, socio-economic aspects and availability of treatment technologies.

Future plans for nutrient and pollution management include:

- Define measures to reduce environmental impact from using pesticides and chemicals in the agriculture sector.
- Promote good practice for aquaculture in the country.
- Develop a permit system for pollution loading and capacity for pollution.
- Develop a suitable wastewater management for fishing piers (Questionnaire – Thailand, 2021).

3.4.9 Viet Nam

Ambient water quality standards are established for surface water, coastal water and groundwater. There are also standards for effluents with over a dozen regulations governing effluents from various sectors including domestic, industrial and medical wastewater. In general, industries are required to carry out EIA and have to commit to self-monitoring four times a year. If a violation is suspected, the "environmental police," under the Ministry of Public security, may carry out, without prior warning, a compulsory investigation to increase the possibility of identifying possible non-compliance. Currently, about 38.6% of industrial zones have automatic monitoring systems, but none exist in industrial complexes (WEPA, 2018).

Altogether, Viet Nam has 117 plans related to the exploitation and sustainable use of natural resources and environmental protection of the sea and islands, including planning at the national, regional, local and sectoral levels, of which 115 have been issued following the Viet Nam Sea Strategy of 2020. The core role of promoting economic development along the direction of marine economic development includes 15 plans, including five regional plans; seven sector plans, and three marine and island resource protection plans. These plans are implemented together with the "National Green Growth Strategy," not directly addressing marine economic activities, but orients socioeconomic development towards a greener path (WEPA, 2018).

Viet Nam's policies for the marine and coastal environment are ecosystem-based and harmonious with nature, shifting from economic exploitation and environmental pollution to a green economy, investing in natural capital based on the achievements of science and technology. The Government has set out important directions, policies and measures to manage, protect and exploit the sea. Significant for marine economic activities was the Politburo's "Resolution No. 03-NQ/TW" dated May 6, 1993 on a number of marine economic development tasks in the coming years, which affirms that the ocean economy must be promoted in parallel with strengthening the protection of national sovereignty and interests, protecting marine ecological resources and environment, and striving to make Viet Nam become a strong country based on the sea by 2020 (PEMSEA, VASI, and MONRE, 2020).

PEMSEA, VASI, and MONRE (2020) further state that under the realm of coastal and marine economic development, coastal industries should promote investment attraction and developing high-tech and environmentally friendly industries, adjust any plans that use fossil fuels, which may cause environmental pollution and increase greenhouse gas emissions. Aquaculture has to be transformed to use modern, sustainable and environment-friendly technologies, and implement energy-saving technologies for fishing to improve production efficiency without negative impacts to the environment.

There are numerous government agencies that oversee some aspects of coastal and marine environments. These include the Ministries of Natural Resources, and Environment and its various departments such as VASI and Viet Nam Environment Administration that advise and assist the provincial people's committees to perform the functions of integrated management of the sea and islands. Twenty-five out of 28 coastal provinces have established sea and island sub-divisions directly under their respective DoNRE, and the rest have Marine and Island Divisions or Marine and Islands unit integrated into some division of their DoNRE (WEPA, 2018).

The General Department of Fisheries and the National Administration of Tourism also implement measures on nutrients and pollution management that are relevant to their areas of jurisdiction in the coastal and marine areas (PEMSEA, VASI, and MONRE, 2020).

In addition to governmental measures to protect the coastal and marine environments, scientific research, marine surveys, and the development of post-graduate human resources are actions that Viet Nam is undertaking to advance its sustainable use of coastal and marine resources.

3.5 Monitoring Programmes

Monitoring of nutrients, water quality, and pollution varies across the region. Coastal and marine water monitoring occur in all countries but remain insufficient in some, e.g. not frequently enough, or not regularly enough in coastal areas. Countries that carry out regular monitoring are looking into improving and expanding their monitoring programmes, such as to gather real-time, *in-situ*, and/or automated provision of data. An overview of the monitoring efforts in each country is listed below with more details included afterwards.

- **Cambodia** - monthly monitoring of freshwater bodies; no regular marine and coastal water quality monitoring system in place yet.
- **China** – monitoring along the coast and the atmosphere over the seas; results are synthesised in the "Annual Marine Bulletin."
- **Indonesia** – each regency and municipal area locally monitors N and P in their coast and in watersheds.
- **Malaysia** – has Marine Water Quality Index and specific island monitoring.
- **Philippines** – Enviroment Management Bureau and its regional offices monitor monthly or quarterly in freshwater & marine areas.
- **ROK** – all coastal areas are regularly monitored with data publicly available online in Korean. The National Institute of Fisheries Science monitors using remote sensing and ocean colour to supplement physical, chemical, and biological monitoring.
- **Singapore** – real-time monitoring of recreational beaches with time data available to the public. Pollution Control Department of the National Environment Agency regularly monitors the water quality of inland and coastal waters.
- **Thailand** – monitors twice a year in the coast with some data available in Thai to the public.
- **Viet Nam** – monitors at least twice a year in the coast; there are also offshore & island monitoring efforts.

Table 10. Monitoring Efforts for Nutrients and Pollution in each Country.

COUNTRY	MONITORING EFFORTS
Cambodia	MOE monitors freshwater bodies once a month for BOD, DO, pH, temperature, TSS, Coliform, TP, TN, and Cr6+ at Phnom Port, Chroy Changva, Ta Khmoa, Kien Svay, Stoung Chenit, Stoung Sen, Stoung Siem Reap, Stoung Sangke, TSL, Stoung Pursat, Kampong Loung, Chhnok Trou, Sesan and Sekong Rivers, Kampong Chhnang and Kampong Cham (WEPA, 2018). MOE also monitors the discharge or transport of effluents from any sources of pollution. The Water Quality Monitoring Network Program of the Mekong River Commission and Ministry of Water Resources and Meteorology (MOWRAM) samples for temperature, pH, TSS, conductivity, Ca, Mg, Na, K, alkalinity, Cl, SO4, Tot-Fe, Si, DO, COD, Mn, NO3-N, NH4-N, PO4-P, and TP with results made public via a database and upon request. The Ministry of Interior is responsible for operation and maintenance of wastewater treatment systems. Sewage Management and Construction Department of the Ministry of Public Works and Transport is response for manage, monitor, control, and evaluate wastewater treatment infrastructure/facilities included develop annual plan for wastewater treatment system. The country does not yet have a regular groundwater quality monitoring system in place (WEPA, 2018), nor regular marine and coastal water quality monitoring system. Monitoring is mostly done in small streams (preaks).
China	The Ministry of Ecology and Environment is responsible for nutrient monitoring and assessment with information reported in the "Annual Bulletin on the State of the National Marine Environment" that is publicly available. Data are kept in National Ocean Data and Information Service Centre. The National Marine Environmental Monitoring Center is responsible for monitoring of the offshore marine environment. Raw data are not publicly accessible. There is a programme for monitoring of nutrient input into the sea and managed areas.

COUNTRY	MONITORING EFFORTS
	In 2019, altogether 1,434 state environmental monitoring sites with following results – 190 sections of rivers entering the sea, 448 points of sewage discharge points with daily discharge of over 100 m^3, 32 areas of bathing beaches had water quality testing. Conducted ecological monitoring on 18 typical marine ecosystems. Monitoring results showed that overall marine environmental quality was moderate to good, with seawater quality improving and meeting Class 1 standards in 97% China's marine areas. Monitoring of atmospheric pollutants over China's main sea bodies is carried out for aerosols and wet deposition (NO3, NH4, Cu, Zn). Most commercial aquaculture enterprises only monitor water temperature, pH, and DO of the aquaculture waters to ensure sufficient growth of the cultured organisms, but generally lack monitoring of nutrients, dissolved organic matters, SS, and pathogens produced from the aquaculture operations. Many mariculture outlets are also not included in the usual water monitoring stations. There is a "Technical Specification on Requirements for Monitoring of Surface Water and Waste Water (HJ/T 91-2002)."
Indonesia	Water quality monitoring schemes are carried out under the Management of Water Quality and Control Over Water Pollution on Government Regulation. Regencies and municipal areas monitor locally, but the provincial government will coordinate when there are more than two regencies within the same province doing the monitoring. Monitoring of water is carried out at least once every six months. Industries are required to send wastewater samples to a registered laboratory once a month or more depending on their activities. The analysis reports are then submitted every six months to local authorities and the MoE. Local and national authorities have the right to access and collect the effluent at any time. The regular monitoring of N and P in the coastal waters are conducted by each Environmental Office of each province and Directorate of Coastal and Marine Pollution and Degradation Ministry of Environment and Forestry. The monitoring is part of

COUNTRY	MONITORING EFFORTS
	water quality monitoring which is regularly conducted every year in selected sites at each of the provincial coastal waters. There are 16 priority watersheds where monitoring is carried out for nutrients and water quality (Directorate of Water Pollution Control/PPA-MOEF): 1) Citarum West Java 2) Ciliwung Jakarta and West Java 3) Serayu Central Java 4) Solo Central Java 5) Brantas East Java 6) Cisadane West Java 7) Kapuas West Kalimantan 8) Siak Riau 9) Musi South Sumatera 10) Asahan Toba North Sumatera 11) Jeneberang 12) Saddang 13) Moyo 14) Way Seputih Lampung 15) Way Sekampung Lampung 16) Limboto Central Sulawesi Besides river monitoring, routine monitoring on water quality and nutrients is also conducted in some coastal seas: • Jakarta Bay - Jakarta • Palabuanratu Bay – West Java • Semarang Bay – Central Java • Surabaya coastal waters – East Java

Malaysia	Water Quality Monitoring is conducted by MONRE's Department of Environment in rivers, groundwater and coastal waters. Monitoring marine water quality has occurred since 1978 in Peninsular Malaysia (WEPA, 2018) and 1985 in Sabah and Sarawak with the main aims to establish the marine water quality status and to determine the degree of pollution from land- and sea-based sources (Malaysia, EPD Sabah, 2003). The Water Quality Index (WQI) is used to evaluate the status of river water quality and corresponding suitability in terms of water uses according to the National Water Quality Standards for Malaysia (NWQS). The WQI for rivers is calculated using the values of six parameters: DO, BOD, COD, NH3-N, SS, and pH (DoE 2012), and according to the index, the status of water quality is classified into three categories: clean, slightly polluted, and polluted. Indicators stipulated in National Water Quality Standards (river) include VOCs, pesticides, heavy metals, anions, bacteria (coliform), phenolic compounds, total hardness, TDS, pH, temperature, conductivity, DO (groundwater) DO, NO3, PO4, NH3, Faecal Coliform, Oil and Grease, TSS (coastal, estuary, inland). The Marine Water Quality Index (MWQI) and monitoring of marine waters is used to assess the status of water quality, detect changes and identify pollution sources. There is the Island Marine Water Quality Monitoring Programme involving 60 stations around 40 islands and regular monitoring of rivers (927 stations located within 120 river basins) (WEPA, 2018). In 2016, 152 coastal, 76 estuary and 90 island stations were monitored, with 608 samples from coastal, 304 samples from estuary and 360 samples from island monitoring stations collected for analysis and reported based on the Marine Water Quality Index. The index was developed based on seven main parameters: DO, NO3, PO4, NH3, Faecal Coliform, Oil and grease, TSS (Marine and Marine Island WQ) (WEPA, 2018). In 2018, an increase in monitoring sites included 188 coastal, 85 estuary and 95 island stations were monitored. As many as 1128 samples from coastal, 510 samples from estuary and 570 samples from island monitoring stations were collected. In the coastal areas, 124 stations (65.96%) as Excellent, 37 stations (19.68%) as Good, 27 stations (14.36%) as Moderate and no station

COUNTRY	MONITORING EFFORTS
	categorized as Poor. 2014 to 2018, the number of stations recorded Excellent category increased from 60 to 124 stations. In island marine waters, 82 stations (86.32%) as Excellent, 8 stations (8.42%) as Good, 5 stations (5.26%) as Moderate and no station categorized as Poor. In estuaries, 18 stations (21.18%) as Excellent, 21 stations (24.71%) as Good, 41 stations (48.24%) as Moderate and 5 stations (5.88%) as Poor. DO, faecal coliform (FC) and phosphate (PO4) are the main variables that affect water quality at polluted or "poor" monitoring stations.
Philippines	Based on the DENR Administrative Order 2016-08 (Water Quality Guidelines and General Effluent Standards of 2016), the Environmental Management Bureau (EMB) is mandated to conduct monitoring of the water quality of fresh and marine waters. The monitoring includes Nitrate as N, Phosphate as P, and Ammonia as N. Under this Order, Nitrate and Phosphate are both classified as primary water quality parameters whereas Ammonia is secondary.Primary parameters are the required minimum water quality parameters to be monitored for each water body while the secondary ones are those other water quality parameters being used for baseline assessment as part of the Environmental Impact Assessment.The Bureau is required to generate at least 10 data sets for primary parameters while 4 data sets are needed for secondary parameters. EMB and its regional offices conduct regular water quality monitoring throughout the country based on the parameters indicated in DAO (DENR Administrative Order) 34 as amended by DAO 16-08. From 2001 to 2016, 238 water bodies were monitored either for classification or for regular water quality monitoring. Depending on the resources, monitoring is carried out monthly or quarterly in accordance with the DENR-EMB Water Quality Monitoring manual.

COUNTRY	MONITORING EFFORTS
	Effluent monitoring can only be carried out by the subjects needing to comply with effluent standards themselves, in principle. A manual on effluent monitoring was issued by DENR-EMB in 2009. In order to determine compliance by industrial establishments, a series of surveys and follow-up inspections are conducted by one of DENR's 16 regional offices. EMB also conducts regular monitoring and sampling of industrial effluents for analysis by EMB's laboratories nationwide in which the results are used for litigation purposes.
Republic of Korea	Monitoring water quality occurs in groundwater, public water bodies, effluents and basin wide. There are two monitoring frameworks for nutrients in ROK. For riverine or watershed environment, the National Institute of Environmental Research (NIER) is responsible for gathering and assessing the information on nutrient, and provide them to the public through the Water Environment Information System (http://water.nier.go.kr/publicMain/mainContent.do). For coastal and marine environments, Korea Marine Environment Management Corporation (KOEM) and National Institute of Fisheries Science (NIFS), formerly known as National Fisheries Research and Development Institute-NFRDI, carry out the same tasks and data are available on the Marine Environment Information Portal. (https://www.meis.go.kr/portal/main.do) NIFS has a monitoring programme on coastal and marine areas, using remote sensing to observe ocean colour, red tides, physical variables, fishing grounds, and oil spills. Observation stations cover the entire coastal area of the country. Temperature, salinity, DO, nutrients, zooplankton, and jellyfish are some of the main variables monitored. The Korea Oceanographic Data Center (KODC) has extensive oceanographic data available to the public as ASCII or Excel format. There are also publications of news bulletins, weekly reports, newsletters, and annual reports on the oceanographic conditions in Korean waters and the East China Sea.

COUNTRY	MONITORING EFFORTS
	Raw data services include data on: • 1961~present, monitored 6 times/yr (4 times/yr, East China Sea) • water temperature, air temperature, dissolved oxygen, nutrients, plankton
Singapore	In Singapore water quality issues are managed on a multi-agency basis. At present, Singapore references the ASEAN Marine Water Quality Criteria (AMWQC) and ASEAN Long-Term Goals to benchmark for coastal and inland water quality. The Pollution Control Department (PCD) of the National Environment Agency (NEA) regularly monitors the water quality of inland and coastal waters of Singapore nutrient levels monitored for internal operations and long-term trends analysis. There have been no significant changes in nutrient levels in the coastal waters over the years. Coastal water samples are analysed for metals, total organic carbon, and other physical, chemical and bacteriological parameters. Apart from monitoring for recreational purposes, e.g. use of recreational beaches, data collected from coastal water monitoring is also shared with agencies such as the Singapore Food Agency (SFA) as part of the on-going efforts to monitor the levels of planktons in the sea, which have implications on Singapore's coastal fish farms. In addition, as may be required, NEA also takes grab samples to analyse additional water quality variables, such as heavy metals and VOCs. This is on-going since 9 Mar 2019 at Pulau Ubin and its vicinity, in response to the incident of toxic waste dumping in Pasir Gudang. For coastal waters, regular sampling is carried out along the Straits of Johor and the Straits of Singapore. Physical, chemical and biological variables are analysed to assess water quality. Seven coastal recreational beaches are closely monitored at weekly intervals to assess their suitability for recreational activities based on NEA's recreational water guidelines. There is a continuous water quality monitoring system called Neptune where eight buoy systems

COUNTRY	MONITORING EFFORTS
	are positioned in the straits to monitor physical, chemical and microbiological aspects. Real-time data from these stations are continuously transmitted to an Operational Management System that manages and processes the data to assess if the water quality has been affected by oil spills, eutrophication of seawater, and algae blooms that may affect fish farms located at coastal waters. PUB (Singapore's national water agency) carries out nutrient monitoring and assessment programmes for seawater quality for the desalination plant operations. These data are not publicly available, but are shared among relevant government agencies. https://www.nea.gov.sg/our-services/pollution-control/water-quality/recreational-beaches/beach-short-term-water-quality-information - data available to the public on recreational beach water quality
Thailand	Coastal water quality samples have been collected twice a year (in dry and rainy seasons) and analysed whether they meet the Marine Water Quality Index (MWQI), a tool developed by the Pollution Control Department (PCD). There are 217 coastal monitoring stations for monitoring marine water quality, carried out by the Department of Marine and Coastal Resources. The data in Thai language can be accessed at: www.pcd.go.th/watertype/แหล่งน้ำทะเล/ (Coastal Water Quality) http://marine.pcd.go.th/main (Coastal Water Quality). Samples are analysed for: • Dissolved Oxygen (DO) • Total Coliform Bacteria (TCB) • Phosphate- Phosphorus (PO_4^{3-} –P) • Nitrate-Nitrogen (NO_3^- – N) • Temperature • SS • Acidity – Alkalinity (pH), and • Ammonia- Nitrogen (NH_3-N)

COUNTRY	MONITORING EFFORTS
	Values range between 0–100, with a score from 0–25 is considered very poor; 25–50 is poor; 50–80 is fair; 80–90 is good; and 90–100 is excellent (PEMSEA and DMCR, 2019). PCD monitors inland WQ four times a year for NH_3, TN, and TP at 375 stations. Data in Thai can be accessed from http://iwis.pcd.go.th/index.php.
Viet Nam	Viet Nam has a Center for Environmental Monitoring under MoNRE. Coastal monitoring is carried out by the Institute of Marine Resources and Environment (north coasts), the Institute of Mechanics (central), and the Institute of Oceanography (south), under Viet Nam's Academy of Science and Technology (VAST). Water samples are collected at least twice a year at 22 stations along the coast of Viet Nam. Monitoring parameters for coastal waters include: • Basic indicators for field measurements: salinity, temperature, pH, DO, turbidity, and TSS • Nutrients: NO_2^-, NO_3^-, NH_4^+, PO_4^{3-} • Total coliform • Heavy metals: copper (Cu), lead (Pb), mercury (Hg), cadmium (Cd), iron (Fe), manganese (Mn), arsenic (As), copernicium (Cn) • Oil and grease The quality of offshore water and water around island areas is monitored by the Center for Marine Environment Monitoring and Analysis of the Naval Forces at 180 points in areas such as oil and gas exploitation areas including DK1, Western Spratly Islands, Western Paracel Islands, Spratly Islands (Big Truong Sa Island, Da Tay beach clusters, Song Tu Tay Island), Colin - Sinh Ton - Nam Yet Island, West of Song Tu Tay Island. The monitoring results show that the quality of offshore water and water around islands is quite good.

3.6 Regional and Global Efforts

3.6.1 Association of Southeast Asian Nations (ASEAN)

The "ASEAN Marine Water Quality Criteria (AMWQC)" was developed from 1992–1997. In 2002, the ASEAN Environment Ministers further endorsed 17 variables as common marine water quality criteria for the protection of the coastal and marine environment in the ASEAN region, where nitrate, nitrite and phosphate are included.There is now an updated "ASEAN Marine Water Quality Management Guidelines and Monitoring Manual" that includes a monitoring manual and various methodologies for lab analyses of water samples (ASEAN, 2008). The publication includes methods for programme design, field sampling and data analysis protocols, QA/QC, data interpretation, reporting, and information dissemination. There is a chapter dedicated to nutrients sampling.

3.6.2 Regional Capacity Center for Clean Seas (RC3S)

At the 24th COBSEA IGM held in Bali, Indonesia, from 19-20 June 2019, the Indonesian Delegation presented a working document to establish the Regional Capacity Centre for Clean Seas (RC3S) in Bali. The meeting encouraged Indonesia to further develop the Centre with the aim at establishing a COBSEA Regional Centre which is located in Bali. It serves as a hub for capacity building, knowledge management and awareness raising related to land-based sources of marine pollution, with work focus on nutrients, wastewater, marine litter and microplastics, and emerging pollutants (RCS3 website).

3.6.3 UNEP Caribbean Environment Programme (CEP)

CEP is one of the UNEP-administered Regional Seas Programme with a long history of addressing pollution in the Caribbean region. The "Cartegena Convention and Land-Based Sources Protocol," a legally binding, regional multilateral environmental agreement that provides a framework for the prevention, reduction and control of pollution from excess nutrients. The Protocol Concerning Pollution from Land-Based Sources and Activities lists primary pollutants of concern including N and P included, outlines processes for developing regional standards and practices for the prevention, reduction and control of the sources and activities; and establishes specific regional effluent limitations for domestic sewage. Annex IV specifically refers to agricultural non-point sources of pollution and states that the Parties shall develop plans for the prevention, reduction and control of agricultural non-point sources of pollution, with specific issues that should be included in the Plan detailed in the Annex (United Nations, 1999).

Most of the CEP Member Countries are developing and implementing National Programmes of Action (NPAs) for the prevention of pollution from land-based sources and activities. They are now also developing a regional nutrient reduction strategy and action plan with a goal to establish a collaborative framework for the progressive reduction of impacts from excess nutrient loads on priority coastal and marine ecosystems in the Wider Caribbean Region. The draft document contains strategies to address:

- Sustainable nutrient management in agriculture/livestock farming;
- Minimising nutrients in effluent (domestic wastewater) and industrial discharge;
- Reaching acceptable environmental quality of coastal waters for designated uses;
- Maintaining healthy and productive coastal and marine habitats;
- Reducing risks to human wellbeing and the blue economy; and
- Enabling effective implementation of a regional nutrient reduction strategy.

3.6.1 UNEP Northwest Pacific Action Plan (NOWPAP)

Another UNEP Regional Seas Programme, NOWPAP (Northwest Pacific Action Plan), had developed procedures for assessing eutrophication including the evaluation of land-based sources of nutrients for the NOWPAP region ("NOWPAP Common Procedures") in 2014. NOWPAP is currently developing a near real-time monitoring system for marine and coastal eutrophication using Google Earth Engine. In the past, coastal eutrophication was assessed using satellite chlorophyll-a data, but data were only available up to 1 km resolution. The new project uses a finer spatial resolution dataset to develop a real-time monitoring tool for eutrophication assessments at the global scale. An interactive app is expected to be fully functioning by 2022 that will cover all global oceanic areas to help NOWPAP Member States and countries around the world to manage eutrophication. As of this report's preparation, there is a map showing potential eutrophication zones in the NOWPAP region. Users can select layers and dates to show areas of eutrophication, hypoxia sites, red tide events (https://cloudgis.nowpap3.go.jp/en/map-pez/).

3.6.2 UNEP South Asian Seas Programme (SAS)

UNEP's South Asian Seas Programme (SAS) administered by the South Asia Co-operative Environment Programme (SACEP) Secretariat[5] has engaged in nutrient loading and eutrophication studies through LME Projects (BOBLME, 2014), the establishment of the South Asian Nitrogen Hub (see section 3.6.4 on "UNEP/GEF INMS Project) and other mechanisms listed below.

A scoping study examined the problem of eutrophication of coastal waters for the maritime countries of South Asia. The study shares information on the status and trend of nutrient pollution in each SAS country, challenges and gaps, policies to address gaps, and recommendations.

The "Lake Chilika Ecosystem Health Report Card" is an example that can be applied in lakes and bays worldwide. Environmental report cards are transformative assessment and communication products that compare environmental data to scientific or management thresholds and are delivered to a wide audience on a regular basis. They can help facilitate science to become policy relevant. In Lake Chilika, the project compared biological, physical, and chemical data (water quality index, biotic index) from monitoring stations with threshold values to assess the lake's health with a grade of A to F given. The monitoring results are used to ascertain the health of the lake, determine the transport of nutrients from rivers into the lake, and guide policy to better manage the lake's health.

3.6.3 UNEP/GEF GNC Project

The project named, "Global foundations for reducing nutrient enrichment and oxygen depletion from land-based pollution, in support of Global Nutrient Cycle" provided the foundations (including partnerships, information, tools and policy mechanisms) for governments and other stakeholders to initiate comprehensive, effective and sustained programmes addressing nutrient over-enrichment and oxygen depletion from land-based pollution of coastal waters in Large Marine Ecosystems. The project developed and applied quantitative modelling approaches to:

- estimate and map present day contributions of different watershed based nutrient sources to coastal nutrient loading and their effects;
- indicate when nutrient over-enrichment problem areas are likely to occur; and
- estimate through modelling, the magnitude of expected effects of further nutrient loading on coastal systems under a range of scenarios.

[5] SACEP is one of the 18 UNEP Regional Seas Programme.

Implementation in the East Asian Seas region, specifically in the Philippines, saw the application of tools and modelling techniques in Manila Bay watershed to produce actual nutrient reduction strategies both for mainstream adoption in that area, and a model for the development and application of nutrient reduction strategies in other regions (UNEP/GEF, 2018). Furthermore, an Ecosystem Health Report Card was produced for Laguna de Bay, giving information on WQ and fisheries indicators, and a score for the East, South, Central and West Bay areas. The report card also gave results on initiatives for awareness raising activities, stakeholder cooperation, and technology to restore WQ (LLDA, 2018).

3.6.4 UNEP/GEF INMS Project

The Project titled, "Targeted Research for improving understanding of the Global Nitrogen Cycle towards the establishment of an International Nitrogen Management System (INMS)," established a South Asian N Hub to develop a more coherent picture of the N cycle. The project quantified N flows and impacts and explored how to improve N management in agriculture and the wider circular economy to reduce the need for synthetic fertilisers by making better use of manure, urine and the natural nitrogen fixation processes. A global assessment of the threats and benefits of human alteration of the N cycle and the opportunities for improvement is provided, as well as a forward look to what may happen if the problem is ignored (INMS website).

The Hub studies the impacts of different types of pollution for a better understanding of and formulation of a more coherent picture of the N cycle. Specifically, it is examining the role of N in agriculture in Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka (all SACEP Member countries), and providing options for more profitable, efficient, and cleaner farming. The Hub is examining how N pollution can be "recycled" back into fertiliser use, e.g. by capturing NO gas from industries and converting it into NO_3^-. It is important to note that all the SACEP countries are included, and this will have far-reaching impacts for the region's efforts on N pollution management, as lessons and good experiences can be shared, as well as seeing how to overcome any cultural, economic and environmental differences that might prevent better management practices from being adopted. The Hub is also a good model on how international efforts on common problems can be solved, as it provides a platform bringing together a wide range of researchers across different cultural and economic backgrounds, working towards better cooperation across science and policy in South Asia, such as guidance on linking mitigation and adaptation options and strategies to circular and green economy. The Hub's efforts also support progress towards meeting SDGs, development of a cleaner, circular economy for N, and demonstrates the economic benefits of tackling N pollution, particularly to policy makers.

INMS has a regional demonstration site in Eastern Europe that focuses on obtaining better understanding of N flows within the region and identifying opportunities to improve N management across sectors, examining run-off from agricultural lands and N delivery from municipal untreated, partially treated and treated wastewater discharge into the rivers and the Black Sea. The outputs of the project will assist the Black Sea Commission to develop regionally specific management plans for reactive nitrogen and ensure good WQ for human health and recreational use and aquatic biota (INMS website, Black Sea Commission website).

3.6.5 UNEP-GPA GPNM

Under UNEP's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), there is the Global Partnership on Nutrient Management (GPNM) that is a partnership of governments, scientist, policy makers, private sector, NGOs and international organisations. The partnership addresses the "nutrient challenge", i.e. the gap between the environmental impacts arising from the demand for food and nutritional needs. A collection of project initiatives under GPNM addresses the following topics:

- Tackling solid and waste pollution in Vihiga County, Kenya.
- Helping smallholder farmers in Kenya to profitably and sustainably access and utilise phosphorus fertilizer.
- Fostering the effective management of, and scientific research on HABs in order to understand their causes, predict their occurrences, and mitigate their effects (in collaboration with UNESCO-IOC).
- Valuating nutrient management in the Upper Pantanal, Brazil, specifically investigating options for improvement NUE and quantifying the costs & benefits of nutrients management.
- Addressing wastewater and other land-based sources of marine pollution that impact coral reefs in Sri Lanka.
- The GNC and INMS projects mentioned above.

GPNM has also established a Task Team on Phosphorus and is collaborating on the project, "Our Phosphorus Future" that aims to:

- Raise awareness of the priority issues, possible solutions and co-benefits of delivering global phosphorus sustainability;
- Bring together scientific evidence to support policy development; and
- Contribute to consensus development around the scientific base and the issues identified.

GPNM will provide training on P management within the framework of the Africa Nutrient Management Platform (el-Habr, 2020). UNEP and its partners have also come up with a number of priority actions to address P management that can be considered for utilisation in the COBSEA region (see Chapter 5). A synthesis report with accompanying briefing notes for each chapter/theme to communicate the evidence on flows and drivers of the global P cycle is under preparation. This will be used to underpin clear messages on the capacity of changes in societal behaviour to transform the governance of P from local to global scales. It will also guide the international scientific and policy communities to co-develop the next steps towards a robust international process on the science support for policy.

3.6.6 UNEP/GEF South China Sea Project

The first phase of the project, "Implementing the Strategic Action Programme for the South China Sea and Gulf of Thailand (SCS SAP)," developed a nutrient carrying capacity model that links chlorophyll concentrations in specific locations of the South China Sea to land-based nutrient loading. The model ran on Microsoft Excel (including data management, numerical solving, and geospatial visualization) and could estimate the impacts of user-defined nutrient loading scenarios from all major rivers on the nutrient status of the South China Sea at the time of project implementation (http://www.unepscs.org/nutrient_model/). This model is no longer available to the public as the links to the data are not connected, but Phase 2 of the project has a component to, "Strengthening knowledge-based action planning for the management of coastal habitats and land-based pollution to reduce environmental degradation of the South China Sea and Gulf of Thailand." The project's member countries are currently updating National Action Plans to determine what pollution-related activities should be implemented, and plans to model the carrying capacity of the SCS marine basin and estimate the monthly 'effective' loading of total nutrient from any catchment, as point or non-point loading (UNEP/GEF, 2016). As these are still under development, no details can be provided yet, but could be used in the COBSEA region in the near future.

3.6.7 UNEP Transboundary Waters Assessment Programme

The UNEP Transboundary Waters Assessment Programme (TWAP) was a two-year project with the overall objective of producing the first global assessment of all transboundary waters within the following five categories:

1. Transboundary Aquifers and SIDS Groundwater Systems
2. Transboundary Lake Basins
3. Transboundary River Basins
4. Large Marine Ecosystem
5. Open Ocean.

A data portal developed by the project provides a tool that allows users to view the results of the assessments of the five river systems listed above, as well as cross-cutting issues and syntheses of results (http://geftwap.org/data-portal). Meta-data is also included in the database. In particular, users can access information about nutrient and wastewater pollution, checking the water quality, projections to 2030 and 2050.

3.7 Management Tools

Many tools exist to monitor, model and help assess nutrient and pollution levels and their potential impacts to nature and human society. Additionally, inter-disciplinary monitoring including nutrients and physical and meteorological variables can help determine the effects of nutrient enrichment and climate and other environmental changes on HAB occurrences and their impacts (Berdalet, 2015). However, most data series are not long enough to draw clear conclusions, but this is a start.

3.7.1 Global Nutrient Management Toolbox

A Global Nutrient Management Toolbox has been developed by World Resources Institute in collaboration with GPNM that serves as a resource for information about nutrient reduction strategies. It contains a best management practices and policy database searchable by agriculture, urban area, climatic zone, land use, policies, and other sectors. The database can calculate N and P loads in river basins by input source and can model best management practices and show loads and N:P ratios. Farmers and extension agents can use the practice database to learn about conservation practice options. The Toolbox calculator allows users to explore nutrient loading implications of their management decisions and simulate alternate scenarios. Decision makers can use the policy database and case studies to learn about programs and policies in areas beyond their immediate workspace (Jones, 2015).

3.7.2 HydroATLAS

High-resolution and accurate hydrographic information are becoming more available and allow the delineation of watershed boundaries and river networks from global digital elevation models. The HydroATLAS database provides a single, comprehensive and consistently organised global data set for all watersheds and rivers of the world at sub-basin and river reach scales (Linke *et al.*, 2019). The data were compiled from publicly available data sources and organised into six categories:

- Hydrology;
- Physiography;
- Climate;
- Land cover and use;
- Soils and geology; and
- Anthropogenic influences.

The database is accessible at https://www.hydrosheds.org/.

3.7.3 Integrated Model to Assess the Global Environment Model

This is the "Integrated Model to Assess the Global Environment" that simulates human activity impacts to the environment (IMAGE website). Components of the model include agriculture, land-use, livestock, nutrients, drivers, and impacts, amongst others. The model can analyse large-scale and long-term dynamics and impacts of global changes that result from interacting socio-economic and environmental factors to gain better insight into the processes of global environmental change. It can identify response strategies to global environmental change based on assessment of options for mitigation and adaptation, and can also show the interlinkages and associated levels of uncertainty in global environmental change. The model can help policy makers to predict the future following the status quo or how taking actions through implementing appropriate policies and measures will prevent unwanted impacts on the global environment and human development. Although not all of the models are downloadable due to their complexity and require expert skills to use, all the scenario data are available to the public.

3.7.4 NEWS - A Global Watershed Nutrient Export Model

The NEWS model was first developed around 15 years ago by a work group of UNESCO's Intergovernmental Oceanographic Commission (IOC), with co-sponsorship by UNEP, US-NSF, and US-NOAA, and is now updated to provide a spatially distributed global view of N, P and C export by world rivers to coastal systems. The large spatial variation in N yield reflects the variable magnitudes of the different nutrient sources and controlling factors among watersheds. This stresses the importance of the need for a clear understanding of the nutrient sources and controls at many scales in order to develop effective policies and implementation strategies to control coastal nutrient loading. The latest NEWS model assesses river export of multiple nutrients in a consistent way and can predict the fate of different nutrient forms. The prediction function of the tool can examine polices in their impacts to reduce coastal eutrophication at regional to global scales (Mayorga *et al.* 2010).

4. Gaps and Opportunities in Nutrient Management

The impacts of N and P traverse various domains such as air, water, food, human health, the coasts and oceans. Addressing the impacts is not always straightforward as domestic policies are sometimes fragmented across different agencies' and their area of jurisdiction. Gaps can be found in technical and governance issues to address nutrient and pollution. At the regional level, nutrients management can benefit from strengthened coordinated regional level responses to complement ASEAN's WQ monitoring and guidelines.

The common gaps and/or areas that can be strengthened in the COBSEA countries are listed below.

<u>Insufficient Data and Information</u>

There seems to be a plethora of data and information on nutrient sources and coastal impacts and individual research and projects, but the data availability varies in each country, is often dispersed, and not always compiled into a consistent database so that nutrient sources in specific locations can be linked to impacts in their associated coastal system. There is a real lack of scientific information required for managing and reducing pollution at regional level. This includes information on pollution hotspots, and on how and where pollution might be decreased on land, in rivers and in the sea. There is also a perceived lack of information where the information does exist, but is not widely disseminated or available, or is not in a useable format. This type of information includes knowledge on clean technologies for industry and treatment of wastes, and best practices for agriculture and aquaculture.

Some countries do not have enough manpower, technical skills, and financial resources for monitoring. This lack of data prevents knowing what actions should be implemented and where. To address pollution at source, there needs to be more monitoring and the provision of information on seasonal and annual variations in pollution loads from land-based activities. Studies on the extent of contamination of coastal sediments as a result of land-based activities is lacking. More information and knowledge is required on nutrient load concentration from aquaculture and mariculture.

Countries with robust monitoring data have expressed the need for a system that provides continuous data series temporally and spatially. Financial and technological support would be required for auto-monitoring and *in-situ* systems to provide real-time data.

As N and P pollution impact human health and the wider environment, more information on and actions to prevent bioaccumulation, bio-concentration, bio-magnification, and trophic transfer of critical pollutants is needed.

With sufficient data and information, contingency planning and early warning and responses can be achieved. Stronger holistic management of N and P, bridging the science-policy divide can also be achieved through more sharing of information across different government agencies.

Increase Awareness and Capacity to Address Nutrients and Pollution

Promoting awareness of nutrients and pollution impacts through information disseminated to the general public can create greater stakeholder involvement and support of pollution reduction programmes. Building awareness can help in creating a foundation for voluntary compliance.

Many countries face insufficient manpower, funds, and skills for analysing nutrients and providing reliable data. Results of analysed water samples should be calibrated, dependable and demonstrate an accurate condition of nutrients and pollutants. Support is needed for increasing capacity of labs to analyse collected water samples to produce consistent results that are regularly calibrated. More capacity and research are needed to estimate the nutrient carrying capacity of water bodies, as well as the transfer of pollutants through the food chain.

Promoting awareness of pollution impacts and the capacity to adapt from and use available global tool kits at national and regional levels, and drawing upon lessons and examples used in other regions such as by SAS, NOWPAP, and CEP can help to fill the data and skills gap (see Chapters 3 and 5).

Improve Understanding of Non-point Sources

More research and training are required to understand how non-point sources are contributing to pollution, thus allowing for more targeted addressing of agricultural runoff from both arable farming and animal husbandry. The lack of sustainable farming technology leads to poor NUE. Skills can be improved and technology provided to "recycle" N wastes. Soft technology such as nature-based solutions (ECE, 2020) should be more widely used solutions to remove excess nutrients from coastal waters through sustainable aquaculture/polyculture of seaweed, seagrass, shellfish farming.

Insufficient Waste Management Approaches

Waste management facilities and approaches to treating wastes before discharge vary widely across the COBSEA countries. Some countries have installed waste management facilities only in localised urban areas while others are available nationwide, but there remains insufficient national budget for wider spatial coverage, treatment types, and discharge data for urban sewerage systems to determine effectiveness and efficiencies of these systems. Stronger integrated management of N and P-sources of waste is need, while more affordable waste treatment technology is still lacking.

Strengthen Law Enforcement

All COBSEA countries have laws addressing aspects of water pollution, waste management, environment protection, also various strategies and action plans governing pollution management (See Annex 3), and laws can always be updated to match changing situations. There remains a need for stronger enforcement and punishment of pollution violators. Stronger enforcement actions include patrolling and inspection of pollution sources, although there remains an overall lack of budget and manpower to patrol. More stringent control is needed in approving and updating waste discharge permits. More responsibility should be put on a polluter pays principle. There is still an overall lack of self-regulation for compliance in industries.

Insufficient Insitutional Harmonisation

There are gaps in the effective institutional harmonisation between government agencies, among NGOs, and between governments and NGOs. Addressing these governance issues is crucial to the development of better-targeted policies for improved nutrients and pollution management that link to broader social and political conditions of countries. Capacity building, awareness raising and public participation, stronger enforcement mechanisms, financial infrastructure, contingency planning, early warning and emergency responses, and research are necessary to achieve this.

Further details on gaps and opportunities shared from each country and from the literature review are described below.

4.1 Cambodia

There is a lack of robust monitoring to regularly assess the status of habitats, protected areas, and marine water quality (PEMSEA, 2019). An environmental monitoring system needs to be set up, with facilities and skilled staff. Databases and statistical information are needed for marine and coastal ecosystems, fisheries, and environmental accounts as well as ongoing initiatives to monitor trends, changes, and progress in achieving SDGs, international commitments, and assess the gaps, benefits, outcomes and impacts. It is critical to also invest in wastewater and stormwater treatment facilities and look into a more integrated waste management system.

4.2 People's Republic of China

There are gaps in data and information because there are insufficient resources to monitor all nutrient source, and not all mariculture outlets can be monitored. However, there are efforts to gradually shift to more sustainable aquaculture practices such as promoting MSC and ASC licensing, that bring in enough revenue with decreased negative impacts to the coastal and marine environment (CAPPMA, 2019).

As fertliser use in China is very high, there is a need to strengthen research on non-point sources of pollution and promote more modern practices that improve seed and crop management (FIO pers. comm.). Regional and international cooperation platforms can help to facilitate and promote *in-situ*, real-time monitoring techniques and information sharing among countries and regions (NMEMC, pers. comm.).

4.3 Indonesia

Indonesia recently issued Government Regulation No. 22/2021 on the Administration of Environmental Protection and Management that not only addresses regulations, but also covers enforcement measures and improving pollution management facilities including wastewater management. However, nutrients management is still part of water pollution monitoring systems and should be mainstreamed specifically for nutrients pollution reduction management. The term, "nutrient pollution" is not explicitly mentioned and it is still considered part of water pollution in general.

Measures for nutrient pollution reduction of point sources are strong as the Indonesian government already has a mechanism on monitoring obligation by industries that produce N and P stipulated as a mandatory action in their production license and permit (Questionnaire – Indonesia, 2021).

Indonesia emphasises strong coordination with GPNM and engaging with regional mechanisms, including RC3S to participate in further studies and work through: (1) providing a service point for knowledge management and other data-related needs for the region; (2) storing and mirroring regionally agreed open data sources; (3) serving as a platform offering technical assistance and information on pollution management.

4.4 Malaysia

Although the Environmental Quality Act 1974 was successful in reducing pollution to a certain extent through controlling point and non-point sources, and frequent monitoring and assessment of the water environment, challenges still need to be addressed for improved water management and pollution control. Some of the gaps include:

- Industries to take on more responsibility and include regulation elements in their operations.
- Weak enforcement and compliance monitoring.
- Technological improvement to reduce the costs of pollution control.
- Better management of lakes and reservoirs to control pollution sources (WEPA, 2018).

4.5 Philippines

Currently, Philippine's regulations on nutrients include only N and P, with focus mainly on nitrates, total reactive phosphates and ammoniacal nitrogen only. Other forms are not yet covered by existing regulations. There is not much regulatory control on domestic sources of N and P compared to industries. There is a need for more infrastructure and funds to establish additional wastewater treatment facilities and sustain their operations. There is also a need to ensure that provisions for wastewater management are included and are practiced in local building requirements particularly in rural areas.

Laboratories of the EMB, as a regulatory agency, should be strengthened for more industrial monitoring as well as increasing the manpower of the EMB Regional Offices involved in monitoring. More variables should be included for monitoring recreational waters to obtain a more complete picture of the WQ.

When Local Government Units issue development permits, these should include EMB criteria on pollution abatement and control to meet environmental laws. Particularly the requirement for Discharge Permit and provision for wastewater treatment must be further institutionalized (Questionnaire – Philippines, 2021).

4.6 Republic of Korea

In Korea, reducing pollutants only from land-based sources was a past focus, but now has expanded to linking riverine and marine water quality management. From the perspective of science and policy to clean coastal waters, a broader vision to include other issues is included such as the need to review the measurement method, modelling tools, coordinated monitoring between riverine and marine systems, and linkages to legislation and management actions (Questionnaire-ROK, 2021). There are still areas for improving pollution management in Korea including:

- Improving compliance to laws and regulations in all sectors of human activities.
- Stronger commitment to improving solid waste management, especially in the construction and municipal area to reduce inputs of solid waste to the seas where it interferes with recreational and fishing activities and can present hazards to navigation.

Two suggestions put forth by the ROK expert were: 1) to establish buffer zones between farms and adjacent water bodies to absorb some contaminants from agriculture; and 2) China and ROK might wish to consider a bilateral agreement to address pollution, either independently or through a regional umbrella organisation.

4.7 Singapore

N and P pollution is within control in Singapore, as there are strict measures to control these nutrients at source on land. However, various government agencies need to work more closely with one another on sharing of monitoring information to ensure nutrient levels are effectively managed.

There is a challenge to maintain or further improve the nutrient status in the catchment in view of factors such as increasing urbanised water catchment area, aging infrastructure, climate change, and human behaviour. Therefore, these nutrient management strategies are required to be constantly reviewed for improvement. The strategies adopted in Singapore are good models for water authorities, policymakers, and practitioners in many other countries as they design and implement policies and practices to meet their nutrient management objectives (Goh and Sim, 2016; Questionnaire – Singapore, 2016).

4.8 Thailand

A major gap for Thailand is insufficient data as monitoring of marine waters is carried out only twice a year due to limited budget. Thailand also needs improved technology for wastewater treatment to reduce N and P. The country is looking towards promoting the reuse of treated wastewater from agriculture or food processing industries by establishing measures for effective utilisation of recycled water without impacts to the surrounding environment. Thailand focuses its efforts on reducing nutrients from industries, non-point sources, household wastewater and improving household water consumption efficiency (Questionnaire – Thailand, 2021).

Cooperation among Local Administrative Organisations, communities and relevant organisations to protect water resources and improve more water bodies to attain “good” and “very good levels” can be improved, while also helping Local Administrative Organisations build on-site, community-clustered, or central wastewater treatment plants to reduce pollutant loads (WEPA, 2018).

Thailand’s Environmental Management Plan (2017-2021) addresses issues of waste management and recycling and aims for 80% of water resources classified as “good” quality, but there are no specific actions to combat nutrient pollution or marine water pollution (ONEP, 2017).

4.9 Viet Nam

Similar challenges as already mentioned above remain for nutrient and pollution management and overall environmental protection. In terms of legislation gaps, laws can be slow to be put into practice and difficult to implement due to lack of specific guidelines in strategies and action plans, thus a review and streamlining of policies and laws is needed to ensure their effectiveness and efficiency. Specific to marine areas and islands, the cross-sectoral coordination mechanism for integrated management of these areas has not been clearly and specifically institutionalized in laws, and thus is not very effective. Increased cooperation across government departments, sharing of information and experiences, elevated human capacity and financial resources to ensure compliance with laws, increased awareness and information sharing to the public, and more scientific research contributing reliable data and solutions are all areas that can be strengthened (WEPA, 2018).

5. Proposed Regional Responses

This chapter proposes regional responses that can help fill the gaps for better nutrients and pollution management that can be implemented by COBSEA. The actions proposed are based on the gaps identified in the countries, and also are actions that would meet the COBSEA Strategic Directions focus to address land-based pollution through implementing the umbrella activities of developing regional guidelines; exchanging policy, information, and best practices; and capacity building and technical training.

Monitoring and Assessment

i. Insufficient data and monitoring are major gaps for some countries. COBSEA can support more robust and long-term monitoring programmes in countries that require this and/or improve on existing ones. Monitoring the sources of nutrients will be particularly useful to manage nutrient leakage from fertilizer use. Support to research and monitoring on seasonal variations also needs to be filled, with a look into whether more advanced monitoring technologies such as if piloting real-time *in-situ* procedures could be a new regional initiative. Regional periodic assessment based on harmonised national monitoring programmes and research can assist to compare monitoring effort across countries.

ii. Instituting a programme on Ecosystem Health Report Card as done by the GNC Project is an alternative way to monitor the health of water bodies with results used to influence policy and elevate confidence among stakeholders of the area being monitored.

iii. COBSEA can draw from NOWPAP's "Common Procedures" to develop harmonised regional methods providing comparable data for assessing eutrophication. This can fill data gaps and provide information on the impacts of land-based pollution to coastal areas.

Research and Knowledge Sharing

i. Further research and capacity building is needed for a variety of issues including for NUE. Under a regional project, COBSEA countries could quantify the usage chain of nutrients for better understanding and optimisation and less waste of nutrient cycles, particularly for food requirements. N and P necessary for food production should be captured and recycled. Target setting for NUE along with integrated R&D efforts can be initiated to increase NUE while also preventing nutrient leakage to the environment.

ii. COBSEA can provide opportunities for countries to exchange experiences, policies, and information on research of non-point sources, recycling technology for returning N wastes back to agricultural use, appropriate and cost-effective technology for waste treatment, and estimating the carrying capacity of water bodies especially transboundary ones. Sharing of outputs, results and best practices addressing land-based sources of pollution would help to fill data and capacity gaps.

iii. Other knowledge exchange topics (and capacity building efforts) can include developing realistically reachable WQ standards, setting harmonized coastal WQ criteria, setting pollution reduction targets, and developing monitoring programmes (see above).

Data Services and Tools

COBSEA can assist countries to adapt and use existing tools, as applicable, that have been developed by other projects and programmes.

i. Scoping studies on nutrients status can help fill data gaps. Secondary data can complement the scoping studies. Some global toolsets are listed in Chapter 3 (GPNM Toolbox, HydroATLAS, IMAGE, NEWS, TWAP data portal).

ii. The INMS Project developed tools and methods for regional N assessment, and water and air quality assessment with future scenarios such as for HABs to be modelled, with the East China Sea as a demonstration region. Further refinement of regional N assessment can be piloted and tested in other marine areas in COBSEA countries.

iii. The SCS-SAP Project is developing an ocean model and when finalised, this and other outcomes from the Pollution Component of the project can be sustained by COBSEA for longer-term implementation of the SAP.

iv. NOWPAP's Eutrophication Tool will become available globally and COBSEA can assist countries to use this for eutrophication alerts and fill monitoring gaps. The tool can be linked to developing a eutrophication early warning system for preventive actions against algal blooms.

Capacity Building

i. Waste discharges from aquaculture are not always treated properly, nor are discharge outlets in the countries monitored robustly enough. Partnering with relevant organisations like FAO and NACA, COBSEA can help countries build capacity for more sustainable aquaculture and monitoring of those sites.

ii. National and other designated laboratories to analyse water quality have to be regularly calibrated to ensure that analytical results fall within acceptable standards. COBSEA can enhance capacity and maintain the calibration skills of labs and lab personnel to be regularly tested to ensure the QA/QC of WQ sample results.

iii. GPNM's P Management Training in Africa and can be re-tailored for COBSEA countries. Such trainings could include: agricultural practices improvement, manure management, developing catchment management approaches, minimising nutrient runoff, P recycling from wastes, developing economic and regulatory policies that lower animal product consumption and waste production.

Regional Hubs

i. Existing centres/hubs such as the R3CS can be a service point for knowledge management and other data-related needs for the region. They can provide a one-stop shopping centre that stores and mirrors regionally agreed open data sources. They can also serve as a platform offering technical assistance and information on nutrients and pollution management for people seeking assistance in this area.

ii. The South Asia N Hub is a good example that COBSEA can replicate. Topics addressed by this Hub, listed in Chapter 3.4.4, provide a good starting point for COBSEA to select the relevant and priority issues to work on.

Integration and Coordination

i. Adequate national and local legislations to implement international commitments have to be put in place and enforced. Support from COBSEA could entail assisting countries to look into their international commitments and identify special areas for legislation, so that legislation can be created or strengthened in these specific areas within a time frame according to the requirement of the international convention.

ii. Expanding on the above, COBSEA can build closer linkages with other UN programmes such as GPA, CBD, and the Regional Seas to further efforts in information and best practices sharing.

iii. The region has some good experiences of stakeholder involvement in pollution management that can be replicated where appropriate. This would help in awareness raising of coastal and marine pollution.

Regional Strategy or Action Plan for Pollution Reduction

Following the model of CEP's "Regional Nutrient Reduction Strategy and Action Plan" (being finalised), COBSEA can begin discussion on whether this would be a feasible and useful initiative. Although COBSEA's focus is on the coastal and marine environments, if a strategy or action plan is to be developed, coordination with upland areas through integrated river basin management will help to better manage freshwater bodies that are the main transport pathways of pollutants to the coastal and marine environment.

Expert Working Group

An immediate response could be to establish an expert working group to prioritise the most urgent actions for the region to undertake. The Group should be the leading body to assist COBSEA in providing technical input on how to implement the actions through new regional projects, and facilitate adaptive management of COBSEA projects as situations in the region changes. The Group should be staffed by consistent participants with the appropriate technical background and available time to follow through regularly in advising and sustaining the agreed actions into the longer-term.

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- South Asian Seas Programme https://eascongress.pemsea.org/sites/default/files/file_attach/PPT-TPW-03-MuhammadKhurshid.pdf
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- UN Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects https://www.un.org/regularprocess/content/first-world-ocean-assessment
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  Parties and signatories available on http://www.basel.int/Countries/StatusofRatifications/PartiesSignatories/tabid/4499/Default.aspx
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7. Annexes

Annex 1 - Acknowledgements and List of Experts Contacted

In preparing this report, there were many people that should be acknowledged for their contribution and guidance in providing the required information. Below in alphabetical order by COBSEA Member State are the names of experts that provided invaluable information to help produce the report. Also included are the participants of the Virtual Workshop that contributed to finalising the report.

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In addition to those mentioned above, other scientists also helped to direct the consultants to sources of information. They are listed below in alphabetical order by first name.

Dr. Cheryl Rita Kuar, Maritime Institute of Malaysia, Malaysia

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Dr. Jae Ryoung Oh, retired, ROK

Ms. Jing Li, CLIVAR, China

Mr. Khim Lay, Oxfam, Cambodia

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List of Participants - Virtual Workshop 3 March 2021

<<Review, add and correct. Consultants do not know who else was present.>

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Annex 2 - Questionnaire for Experts to Provide Information for the Nutrients Desk Study

Thank you for taking the time to provide information for the Desk Review on Nutrient Pollution. There are 15 questions below that will help the consultants synthesise information for the final product.

Please be as specific as possible in your answers and give examples where possible.

Please send your inputs to Ms. Connie Chiang (conniechiang@yahoo.com) and Ms. Saisunee Chaksuin (saisuneec@yahoo.com) before **22 January 2021**. This will be highly appreciated.

1. What are the main sources of N and P in your country? Please define each as land- or sea-based. Please rank L= Low, M= Medium, or H=High for each N and P.

Sources	N	P	Transport Pathway to Coastal and Marine Areas
• Agriculture			
• Aquaculture			
• Industry			
• Domestic wastewater			
• Non-point source			
• Others (please list each one)			

2. What is the fate of N and P? Please be as specific as possible and give geographic/transboundary examples where possible.
3. Where are the coastal and marine nutrient (N and P) hotspots in your country, for both sources and sinks? If you have knowledge on regional sinks, please also share this information.
4. What are the impacts of N and P leakage to coastal and marine environments in your country? Please give specific examples such as impacts on environmental state, ecosystem services, social and economic impacts.
5. What nutrient monitoring and assessment programmes are carried out in your country? Who is responsible? Are data publicly accessible? Where are such kinds of publicly available data stored?
6. Please attach/provide links to nutrient pollution assessments, studies, and other relevant publications.

GOVERNANCE MEASURES

7. What are the existing legislation and policies on nutrient management and prevention and reduction of nutrient leakage/pollution in your country?
8. What are your country's targets for N and P pollution reduction? Please be specific for each nutrient, e.g. loads, concentrations, timelines, etc.
9. What measures are in place for N and P reduction? How effective are they currently? Please share any specific sites where this has been demonstrated.
10. Please attach/provide links to any available tools and guidelines for nutrient management and pollution prevention.
11. Can you share good examples of nutrients management from your country or the region that you are aware of?
12. What are the most critical gaps in addressing N and P pollution, in your country and in the region? Please mentions gaps in data & information, capacity, monitoring, governance, etc.
13. What is the priority for nutrients pollution management/reduction in your country and for the region? Please be specific for each nutrient, N and P.
14. What are some regional level responses you feel are needed for N and P management?
15. Any other information that you wish to share.

Responder's info:

Name: ______________________________

Position: _____________________________

Affiliation: ____________________________

E-mail: _______________________________

Telephone: ____________________________

Annex 3 - Legislation in Each Country Relevant to Nutrients and Pollution

COUNTRY	LAWS
Cambodia	Law on Environmental Protection and Natural Resource Management, Article 1 - Protect and promote environmental quality and public health through the prevention, reduction and control of pollution. Fines are listed in the law. The law was enacted on 24 December 1996 by the National Assembly. Sub-Decree on Solid Waste Management (27 April 1999) Sub-decree on Water Pollution Control (1999) – Regulate water pollution control in order to prevent and reduce pollution of public water areas. Environmental Guideline on Solid Waste Management (2006) Law on Water Resource Management (2007) - To foster the effective and sustainable management of water resources to attain socio-economic development and improve the welfare of the people. Coastal Environmental Management Action Plan (2007–2011) Applies ICM concepts in developing plans and joint decisions on multidisciplinary activities related to forests, fisheries, solid and liquid waste, habitats, and coastal use zoning. National Strategic Development Plans (2009–2013; 2014–2018; 2019-2023) - Reviews all existing regulations, major problems, key stakeholders, and detailed programmes to ensure the improvement and sustainable management of the environment for the benefit of health, society, and the environment. The latest plan states that relevant ministries should regularly inspect pollution sources at factories nationwide, introduces testing of the reporting system of emissions and movements of toxic substances into the environment by major pollutant sources, and inspects environmental pollution crimes. The National Environment Strategy and Action Plan, 2016–2023 (NESAP) has a pollution-related objective to support national line institutions and subnational administrations to improve waste management and achieve Cambodia's reduce, reuse, and recycle targets. It also addresses how to improve the management of chemical and hazardous waste. Phnom Penh Waste Management Strategy and Action Plan of Phnom Penh (2018-2035)

People's Republic of China	● Marine Environmental Protection Law ● Law on the Administration of the Use of Sea Areas (2001) ● Cleaner Production Law ● Water Pollution Control Law ● Air Pollution Control Law ● Environmental Impact Assessment Law ● Regulation for aquaculture and mariculture wastes ● Regulation for Sanitation at Sea ● Plan on Institutional Reform for Ecological Civilization (2015) ● Marine Ecological Civic Construction Implementation Plan (2015) ● National 5-year development plan for 10% reduction of pollutant discharge There are other local legislations related to the prevention and reduction of nutrient loads that regulate the implementation of total-quantity control of pollutant discharge. For example, there is the Action Plan to integrate management of Bohai Sea (2018) with focus on controlling excessive pollutants, cleaning up polluters, identifying sources of pollution and their potential hazards, preventing further pollution risks, issue early warnings, and establish a real-time online monitoring system (MEE, 2018, 2019). There is also the Water Pollution Prevention and Control Action Plan and the Coastal Water Pollution Prevention and Control Plan, and the Hangzhou Bay Pollution Control Plan. Regulating pollutant discharge of mariculture is mainly based on the current discharge requirements of mariculture waters, which is the recommended industry standard issued by the Ministry of Agriculture in 2007. Most commercial aquaculture enterprises only monitor water temperature, pH, and DO of the aquaculture waters to ensure sufficient growth of the cultured organisms, but generally lack monitoring of nutrients, dissolved organic matters, SS, and pathogens produced from the aquaculture operations. Many mariculture outlets are also not included in the usual water monitoring stations.

Indonesia	Main regulations related to nutrient pollution management: ● Government Regulation No.19/1999 on Pollution Control and/or Marine environmental damage. Protection of marine quality; prevention, mitigation of degradation and pollution; and restoration of marine resources ● Government Regulation No 82/2001 about water quality management and water pollution control and are the minimum WQ standards set by the national government. Local governments can set their own standards. ● Law 7/2004 on Water Resources - water resources must be managed comprehensively and integrally from an environmental aspect, with the aim of realising the benefits of sustainable water resources. ● Law No. 27/2007 Jo. Law No. 1/2014 about Coastal and Small Islands Area Management ● Law No. 32/ 2009 about Environmental Protection and Management ● Law No. 32/2014 on Maritime (Maritime Law) ● Solid Waste Management (Law No. 18/2008; Government Regulation No. 81/2012; Presidential Decree No. 97/2017; Presidential Decree No. 83/2018) ● Environmental Minister Decree No 51/2004 Sea Water Quality Standards now replaced by Government Regulation No. 22/2021 on the Administration of Environmental Protection and Management Besides national laws, there are ministerial decrees that control and manage various technical regulation on aquatic pollution prevention and management, marine waters pollution prevention management, domestic waste reduction management, marine pollution management, management of fisheries activities related to management of waste, and many more. Decree 112/2003 - Standard quality of wastewater for commercial and/or domestic activities Decree 5/2014 Industrial liquid waste The policy on nutrient management and prevention and reduction of nutrient leakage/pollution is part of the pollution and environmental degradation reduction policy (Directorate of Coastal and Marine Pollution and Degradation Control/PPKPL-MOEF) to: ● control pollution loads entering marine waters both from point source and non-point source activities ● rehabilitate/restore polluted/damaged coastal and marine areas

	• rehabilitate coastal and marine areas that are experiencing pollution and/or damage. For coastal water quality, there are three sets of standards: Marine water quality standards for ports and harbours (Annex I in MoE Decree 51/2004), standards for marine recreation (Annex II) and standards for marine ecosystems (Annex III). The water quality standards for marine ecosystems notably have individual standards on clarity, TSS, temperature and salinity for coral, mangrove, and seagrass. Indonesia is also a party to several multilateral environmental agreements or international conventions. The UN SDGs (SDG 14 or Life Below Water in particular), Manado Ocean Declaration (MOD) 2009, Changwon Declaration 2012, Sustainable Development Strategy for the Seas of East Asia (SDS-SEA) in 2003 and the updated SDS-SEA in 2015.
Malaysia	Environmental Quality Act (EQA) 1974 (Amendments 2012) on the prevention, abatement and control of pollution, and enhancement of the environment. The act ordains that the minister, after consultation with the Environmental Quality Council, may elaborate regulations for prescribing ambient water quality and discharge standards, and specifies the maximum permissible loads that may be discharged by any source into inland waters, with reference either generally or specifically to the body of waters concerned. Water Service Industry Act (WSIA), which replaced the Sewerage Service Act in 2006. The National Water Resources Policy (NWRP) was launched in March 2012 for the period of 2010 to 2050, and is aimed at determining the future direction of the water resources sector based on a review of national water resources. The formulation of the NWRP provides clear directions and strategies in water resources management to ensure water security and sustainability for humans and nature. For Sabah, there many handbooks and guidelines for environment-related activities such as land reclamation, shoreline development http://www.epd.sabah.gov.my/v1/index.php/documents/guidelines/handbook-guidelines

Philippines	Presidential Decree 984 Pollution Control Law of 1976 Presidential Decree 979 Marine Pollution Law 1976 National Marine Policy, s.1994 Republic Act 9003 also known as the Ecological Solid Waste Management Act of 2000 adopts a more systematic and comprehensive solid waste management program for the purpose of ensuring public safety. DENR Administrative Order No. 27, Series of 2003 – Preparation of Self-Monitoring Reports (SMRs) – provided the basis for requiring the industry sector to submit to EMB quarterly monitoring data of the quality of the facility's generated effluents. It also covers reporting requirements for other environmental laws implemented by the EMB. Republic Act 9275 Philippines Clean Water Act of 2004 and Implementing Rules and Regulations (DENR Administrative Order No. 10, Series of 2005) - provides the legal basis and framework in reducing and controlling water pollution in the country, including a basis for establishment of fines and penalties for pollutive industries. This includes, among others, regulations for nutrient levels in wastewaters/effluents as well as on classifying water bodies relative to the concentrations of different parameters into certain categories that will dictate the effluent standards to be followed by the regulated industries near these water bodies. The implementation of this Act has led to various Orders, Policies, Activities/Projects, and Memorandum Circulars. It also outlines the specific duties and responsibilities of various government agencies and instrumentalities in relation to the implementation of programs and policies to realize the objectives of the enactment of the Philippine Clean Water Act. Department of Agriculture Administrative Order No. 26, Series of 2007 – Guidelines on the Procedures and Technical Requirements for the Issuance of a Certification Allowing the Safe Re-Use of Wastewater for Purposes of irrigation and Other Agricultural Uses - institutionalized as required by the Philippine Clean Water Act and its Implementing Rules and Regulations to cope with increasing scarcity of freshwater for use in irrigation, as liquid fertilizer and for aquaculture purposes. The guidelines require characterization of the wastewater for levels of macro and micronutrients, heavy metals, pH level and other parameters. DENR Memorandum Circular No. 006, Series of 2015 – Guidelines for Recreational Waters Monitoring Program. Streamline processes and procedures in the prevention, control and abatement of pollution

	of Philippines' waters, promote public information and education, encourage participation of an informed and active public in WQ monitoring and management. Section 3.1 states that all recreational waters shall be monitored using the primary parameters that are faecal coliform and pH. DENR Administrative Order No. 08, Series of 2016, Water Quality Guidelines and General Effluent Standards of 2016 – provides updates on WQ parameters that is used as basis for the classification of water bodies according to beneficial use. The values are the basis for comparison of annual monitoring data from the water quality monitoring activities of the EMB to evaluate the status of a particular water body. This Order also prescribes the regulatory standards for the quality of industrial effluents before they are discharged into a specific class of receiving water body. The regulatory standards serve as basis for examining specific parameters in excess of standards during the inspections of industries and in building pollution cases. EMB Memorandum Circular No. 25, Series of 2020 – Guidelines on the Total Pollution Estimates for Freshwater Bodies in relation to its Assimilative Capacity. This provides technical guidance for EMB Regional Offices in determining Total Pollution Load estimates for freshwater bodies, and to determine pollutant contributions from point and non-point sources, assess assimilative capacity for freshwater bodies, and come up with the appropriate strategies for water quality management. EMB took the initiative to develop a National Research and Development Program for the Prevention and Control of Water Pollution (NRDP-PCWP). It is currently in the final stages of its first phase which was started in 2020. So far, the identified areas of concern include water resources, industrial and domestic wastewater treatment systems that meet the General Effluent Standards, agricultural run-off and siltation and ballast water management. The NRDP-PCWP is expected to serve as reference for all interested parties (e.g., academe, government institutions, private sector) in crafting research and development activities that are geared towards addressing issues on water pollution and water resources management. The Bureau is also currently developing a National Action Plan on Land-based Sources of Pollution (NAP-LbP) in coordination with other relevant stakeholders (e.g., academe, government institutions, Non-Government Organizations, etc.). This Action Plan shall serve as basis for other government institutions in crafting policies and programs to address Land-based Pollution particularly in the regions of the country that has water bodies discharging to the West Philippine Sea.

Republic of Korea	Acts and policies related to nutrient management in riverine and coastal environments can be divided into three categories in RO Korea: 1) Laws that provide long term targets, i.e. goals, policy directions and relevant principles for the nutrient management to the public in order to protect environment for better living life: Framework Act on Environmental Policy for Riverine Waters and Act on Conservation and Utilization of the Marine Environment. 2) Laws, related decrees and ordinances that regulate point-sources like wastewater discharge facilities: Standards for Effluent Water Quality for isolated industrial plants and Permissible Discharge Limits for public wastewater treatment facilities in the Water Environment Conservation Act, Permissible Discharge Limits for sewer discharges in Sewerage Act, and Permissible Discharge Limits to control the pollution from livestock in Act on the Management and use of Livestock Excreta. 3) Five laws related to overall Total Pollution Load Management System regulating both point- and nonpoint- sources: Act on Water Management and Residents Support in the Nakdonggang River, Han, Geum, Yeongsang River Basins, and Marine Environment Management Act for regulating five coastal Special Management Areas of Incheon-Shiwha Lake, Masan Bay, Kwangyang Bay, Busan, Ulsan. Environmental Standards for Water Quality and Aquatic Ecosystem (freshwater) ● Marine Environment Conservation Plan ● Complete prohibition of ocean dumping ● Marine Debris Management Plan ● Coastal Total Pollution Control Act ● Designation of Special Area Management; Special Area Management Plan - A seriously polluted area should be designated with these plans put in place – includes sewerage systems and wastewater treatment facilities, Coastal Enhancement Program to address coastal erosion and sedimentation, solid waste separation and collection system. There is the website of Korea Legislation Research Institute, https://elaw.klri.re.kr/eng_service/main.do, that lists laws in English. Other guidelines and Master and Implementation Plans are written only in Korean.

Singapore	Prevention of Pollution of the Sea Act (PPSA), Revised edition 1999 - prohibits placing pollutants into Singapore waters, and discharge oil or oily mixtures, or sediments from land or from an apparatus used for transferring oil or sediments to or from a ship. The Act addresses pollution from land and ships, lists preventive measures against pollution of the sea, and recovery of costs for clean-up. Environmental Protection and Management Act, Part V - Water Pollution Control (Revised Edition 2002) The Environmental Protection and Management Act (EPMA) and the Sewerage and Drainage Act (SDA) and their regulations are used to control the discharge of wastewater from domestic, industrial, agricultural and other premises into public sewers and watercourses. The Environmental Protection and Management (Trade Effluent) Regulations (TER) and the Sewerage and Drainage (Trade Effluent) Regulations stipulate the standards for trade effluent discharged into watercourses and public sewers, respectively. Other relevant policies and initiatives include: • Environmental Public Health Act • Public Utilities Act • Water Quality Guidelines 2008 The Maritime Singapore Green Initiative – comprising the Green Ship Programme, Green Port Programme, Green Technology Programme, Green Awareness Programme and Green Energy Programme provides incentives to companies that adopt clean and green shipping practices over and above the minimum required by IMO.
Thailand	Enhancement and Conservation of the National Environmental Quality Act (NEQA) was passed in 1992 as a basic law for environmental conservation. Factory Act of 1992 – controls factory operations ranging from worker safety to pollution control measures. Roadmap on Waste and Hazardous Waste Management (2014) and National Solid Waste Management Master Plan (2016 - 2021). Reduce amount of accumulated waste; Promote appropriate Municipal Solid Waste and Hazardous Waste Management; Instil National Discipline on “Public Awareness” Strategy for Water Resource Management Act B.E. 2558–2569 (2015–2036) - lays out a policy framework for integrated prevention of and solutions to water resource problems, including water scarcity, flooding and water quality issues. Sub-strategies address

	water management for household consumption, creation of stable water supply for agriculture and industry, flood management, WQ management, conservation of forest watersheds and prevention of soil erosion. 2015 Marine and Coastal Resources Management Act - the first law that specifically aims to protect important coastal and marine resources. The law establishes the National Committee on Marine and Coastal Resources Management which is responsible for: (1) providing planning and policy recommendations on the management of marine and coastal resources and monitor the implementation of relevant agencies; (2) considering and approving on the areas where the prevention measures for coastal erosion should be implemented and; (3) reporting on the situation of marine resources and coastal erosion on an annual basis. Thailand Zero Waste Action Plan (2016-2017) 20-Year Pollution Management Strategy approved by the National Environmental Board on 28 December 2016 with the following principles: • mitigate and control pollution sources from upstream to end-of -pipe • manage pollution at community level by prioritizing the problem • encourage local administrations to mainstream wastewater and municipal waste management in their operations • apply public-private partnerships and economic incentives • develop better streamlined pollution management regulations, plans and implement these across agencies • support stakeholder participation to manage pollution at the community level. Pollution Management Plan for 2017–2021, prepared by the Ministry of Natural Resources and the Environment (MoNRE), approved by Environmental Board in September 2016. Two strategies on pollution management concerning protecting the environment including protection, rehabilitation and restoration, and another strategy that focuses on increasing the usage efficiency of natural resources.

Viet Nam	National strategy on water resources to 2020 (Decision N0. 81/2006 QD-TTg of April 14, 2006). The purposes are to protect, efficiently exploit and develop national water resources; to prevent and minimize harms caused by water; to create a multi-sector water economy. A new Law on Water Resources 2012 (Decree No. 17/2012/QH13) replaces the previous Law on Water Resources 1998 under Decree No. 08/1998/QH10) on issues relating to the protection of water resources including responsibilities for the prevention of water deterioration and depletion, and control of water quality, are significantly highlighted in Chapter 3 of the Law. Decree No. 51/2014/NĐ-CP, dated 21.05.2014, stipulating the assigning individuals and organizations to use the coastal water areas. According to this Decree, the People's Committees of coastal provinces will decide the entrusting of individuals and organisations to use coastal water areas within 3 miles, except for the areas managed by Government and Ministry of Natural Resources and Environment. A new Law on Environmental Protection 2014 (No. 55/2014/QH2013) also provides statutory provisions on environmental protection activities; measures and resources used for the purpose of environmental protection. It stipulates that waste sources discharged from the mainland, islands and marine activities must be controlled, prevented, mitigated and disposed of in accordance with laws. Decree no.80/2014 /ND-CP on drainage and wastewater treatment. Vietnam Maritime Code No. 95/2015/QH13. In this Code, Acts causing environmental pollution are strictly prohibited in maritime activities. The regulations on Environmental Protection in maritime operations are outlined in (Article 128) as follows: • Construction of a ship or seaport must entail installation of environmental protection. • Equipment in accordance with laws and regulations; have oil and hazardous chemical spill response plans. • Seaports must have plans and solutions to receive and treat wastes discharged from ships in accordance with applicable laws. • The ship owner, seaport owner and organizations or individuals involved must comply with laws and regulations on environmental protection.

Annex 4 - List of Tables