The South China Sea and Gulf of Thailand

Transboundary Diagnostic Analysis

Y2K + 25

Climate

Governance

People

Ecosystem Biodiversity

Living Aquatic Resources

Pollution

A Regional TDA through a 25-Year Lens

2000 - 2025

SCS SAP

UN environment programme

gef

UNOPS

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1. Why assess the South China Sea and Gulf of Thailand now?

1.1 TDA-SAP 1.0 (Y2K)

At the turn of the millennium, the first environmental assessment of the South China Sea and the Gulf of Thailand was completed by the UN Environment Programme through one of its regional projects with support from the UN Global Environment Facility (GEF) (McManus 2000). The assessment process was called a transboundary diagnostic analysis (TDA). Its objectives were to identify environmental concerns that crossed national marine borders, and to diagnose the root causes for these. The TDA was followed by a Strategic Action Programme (SAP) through which actions were designed to address such root causes. The SAP Document and recent versions of this became the bases for project support from the GEF in the last 25 years and through which mitigating actions continue to be implemented (GEF Project Documents 885-2004 to 2013, GEF 5538-2015 to present).

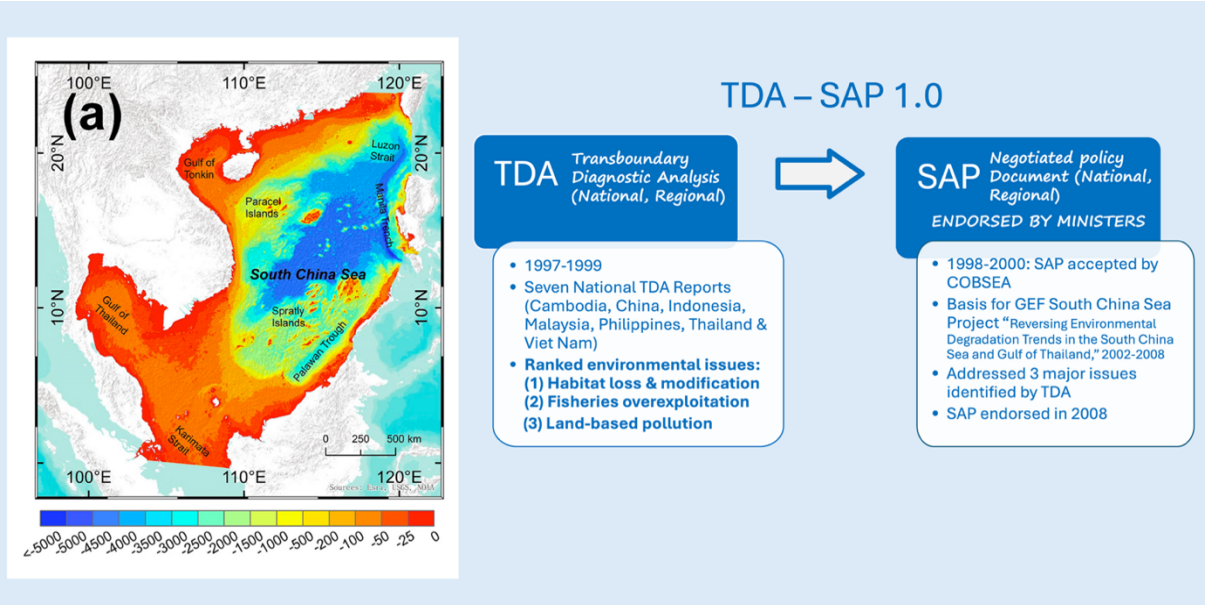


Figure 1-1 The Transboundary Diagnostic Analysis – Strategic Action Planning process for the South China Sea and Gulf of Thailand completed in 2000.

The major transboundary environmental issues the TDA 1.0 identified and ranked by seven participating countries (Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam) were: (1) habitat loss and modification; (2) fisheries overexploitation in the Gulf of Thailand; and (3) land-based pollution (Figure 1.1). The international trade of manufactured goods, living organisms (e.g. fish and shellfish both wild and cultured), derived natural products (e.g. mangrove wood chips), and even illegally traded organisms such as corals, among others, were determined as a major driver of these transboundary environmental issues. Overpopulation, poverty and low governance capacity to plan, enforce laws, and account for environmental costs, were cited as compelling socioeconomic root causes underpinning these transboundary issues.

1.2 TDA 2.0 (2025)

In the last 25 years, earth system science has progressed in modelling and assessing scenarios of climate change and complementary modelling of shared socioeconomic development pathways that contribute to greenhouse gas emissions. Global assessments of planetary limits and social thresholds have shown that the conventional path to socioeconomic progress using fuel fossils for energy has pushed the earth outside of its safe and just operating zone (Rockstrom et al. 2009, Steffen et al. 2015, Raworth 2017, Richardson et al. 2023).

Human activities have breached the limits of climate change, biodiversity loss and nutrient (nitrogen and phosphorus) pollution, including the appropriation of land and water, and the release of synthetic chemical pollutants (Planetary Boundary Science, 2025).

Updating the TDA 1.0 to TDA 2.0 aims to put the triple planetary crises of climate change, biodiversity loss and pollution as framing contexts for examining transboundary environmental problems in the South China Sea- Gulf of Thailand large marine ecosystems (Figure 1.2). As two interconnected large marine ecosystems (LMEs) of sixty-six LMEs that make up the global ocean, it is crucial to determine the states of these LMEs in the contemporaneous global climate scenario. Thus, TDA 2.0 aims to address two critical questions. What levels of social, economic and environmental pressures have been imposed on these systems as amplified by climate change and negotiated appropriately or not by the level of governance capacity at local, national, regional and global scales? ***Are the South China Sea and Gulf of Thailand at risk?***

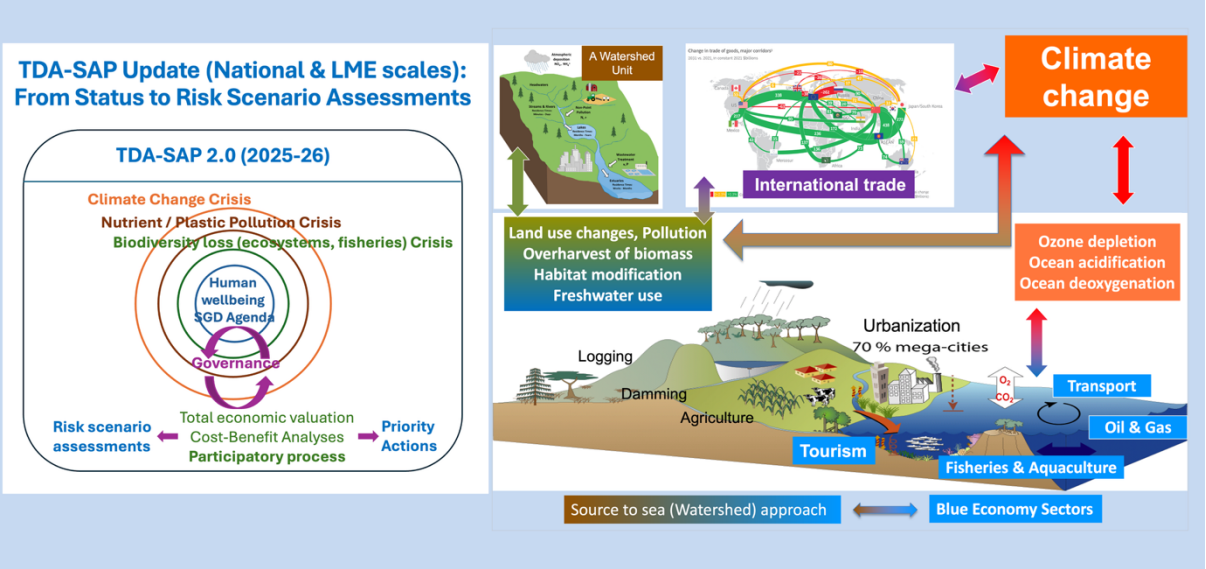


Figure 1-2 Conceptual framework for TDA-SAP 2.0 in the context of the triple planetary crises of climate change, biodiversity loss and nutrient pollution. The organizing concepts of source-to-sea or watershed approach, and economic valuation of blue economy sectors were used in the TDA.

The SCS-GoT assessment and a subsequent preparation of a strategic action programme are two main deliverables of a GEF-sponsored regional project called "Implementing the Strategic Action Programme for the South China Sea and Gulf of Thailand" or SCS SAP Project for short. National TDA-SAP Teams from each of six participating countries (Cambodia, China, Indonesia, Philippines, Thailand and Viet Nam), assessed quantitative indicators at national scales for each of six themes: Climate, People, Ecosystem Biodiversity, Fisheries and Aquaculture, Pollution, and Governance (Figure 1.3). A Project Team of Regional TDA-SAP Experts assembled a core set of indicators for national teams to implement. In addition, the Project Regional Expert Team implemented a similar assessment at large marine ecosystem (LME) scale following a similar set of indicators. This draft Regional TDA Brief encapsulates the main results of the regional analyses and has been prepared for the Third Meeting of the Regional Scientific and Technical Committee of the SCS SAP Project. A full length Regional TDA report is currently in preparation in anticipation of the completion of all six national TDA reports, to allow for intercalibration of emergent assessment features at national and large marine ecosystem scales.

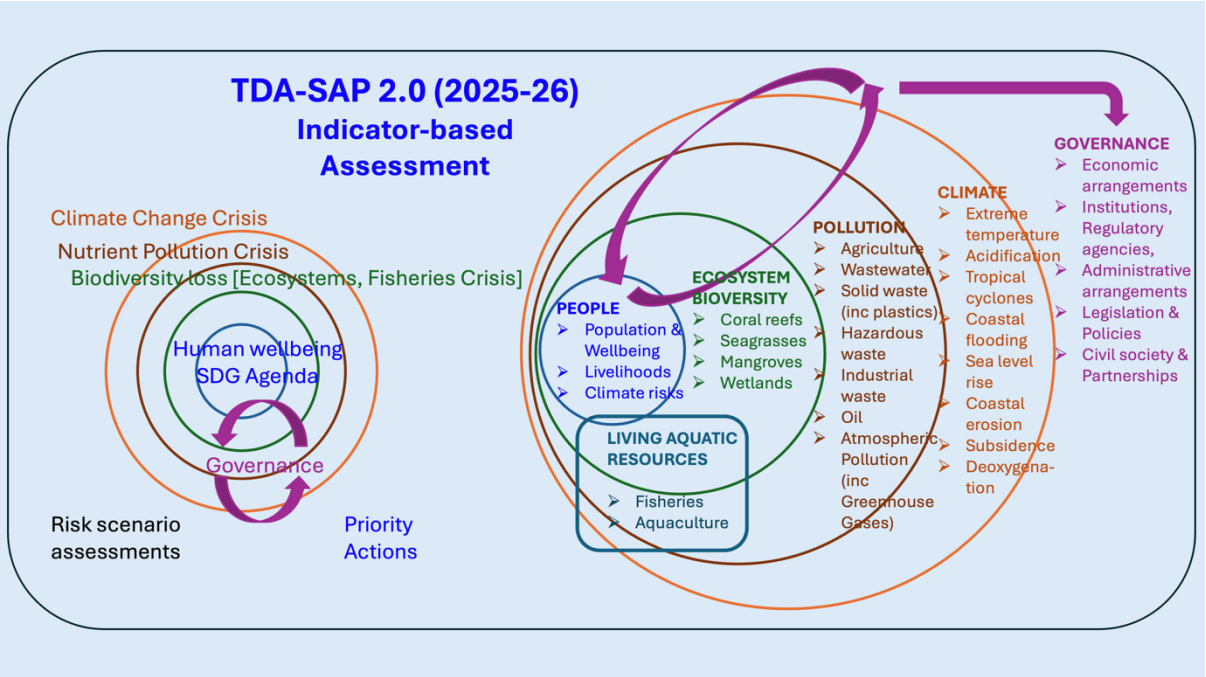


Figure 1-3 The TDA-SAP 2.0 assessment used both quantitative and qualitative indicators in assessing six thematic components of the SCS-GoT large marine ecosystems at the scale of six participating littoral countries, and at LME scale.

1.3 Organization of the Regional TDA (2.0) Brief

For the regional transboundary diagnostic analysis, the socioeconomic and governance components included as study units the following countries: Cambodia, China, Indonesia, the Philippines, Thailand and Vietnam. Malaysia and Singapore, even if they were non-project participants, were included. The sections on pollution, ecosystems and fisheries summarized results at the scale of a large marine ecosystem.

Section 1 provides the motivation for the update and the conceptual framing of the TDA-SAP process. Section 2 describes the regional climate in the context of planetary scale changes and their impacts at regional scale. Section 3 analyzes the socioeconomic changes in the conditions of dependent coastal populations over the period 2000-2025, including their direct physical exposure to climate-induced factors such as storms and floods. Section 4 examines the quality of coastal and marine waters over the same period. Section 5 describes the changes in structure and functioning of critical marine habitats (corals, seagrasses, mangroves and wetlands) in the two LMEs. Section 6 assesses the fisheries and aquaculture industry in the region. Section 7 analyzes the level of governance capacity and extent of collaboration among participating countries to address transboundary and national environmental concerns. Section 8 highlights key recommendations for actions, emphasizing those that are transformative, integrative, strategic and cross-thematic in expected net benefits. A compendium of recommended actions culled from submitted national reports are provided as annex to this report. Four full-length drafts of national TDA reports from Cambodia, Indonesia, Philippines, and Thailand are submitted along with this Regional TDA Brief.

2. How is climate change manifested in the SCS-GoT LMEs?

2.1. Climate change is an earth system change

Climate is defined as the long-term pattern of weather in a particular area and is conventionally tracked for the mean of its measured variables (e.g. temperature, humidity, precipitation, days with minimum and maximum temperature) for at least 30 years. It is determined by interactions among four major interacting components of the earth system: (1) the atmosphere (the air masses and air circulation systems), (2) the hydrosphere (all water on Earth such as the oceans and ocean currents that distribute heat and salt, seas, lakes, rivers, glaciers and water vapor); (3) the litho-/ geo-sphere (land surface, solid earth), and (4) the biosphere (living systems such as biomes and ecosystems which influence energy transformations, the oxygenation of the atmosphere and the chemical cycling of waste).

Climate change is a collective term applied to long-term changes in temperature and weather patterns. Earth system scientists have defined a safe operating space within which earth system processes remain functional and sustaining for the biosphere. A stable climate where energy intake and release are stable, is requisite to planetary wellbeing. Today, human activities have altered all four planetary spheres, resulting in earth system processes operating beyond safe biophysical boundaries, including and most significant of all, a warming climate (Figure 2.1).

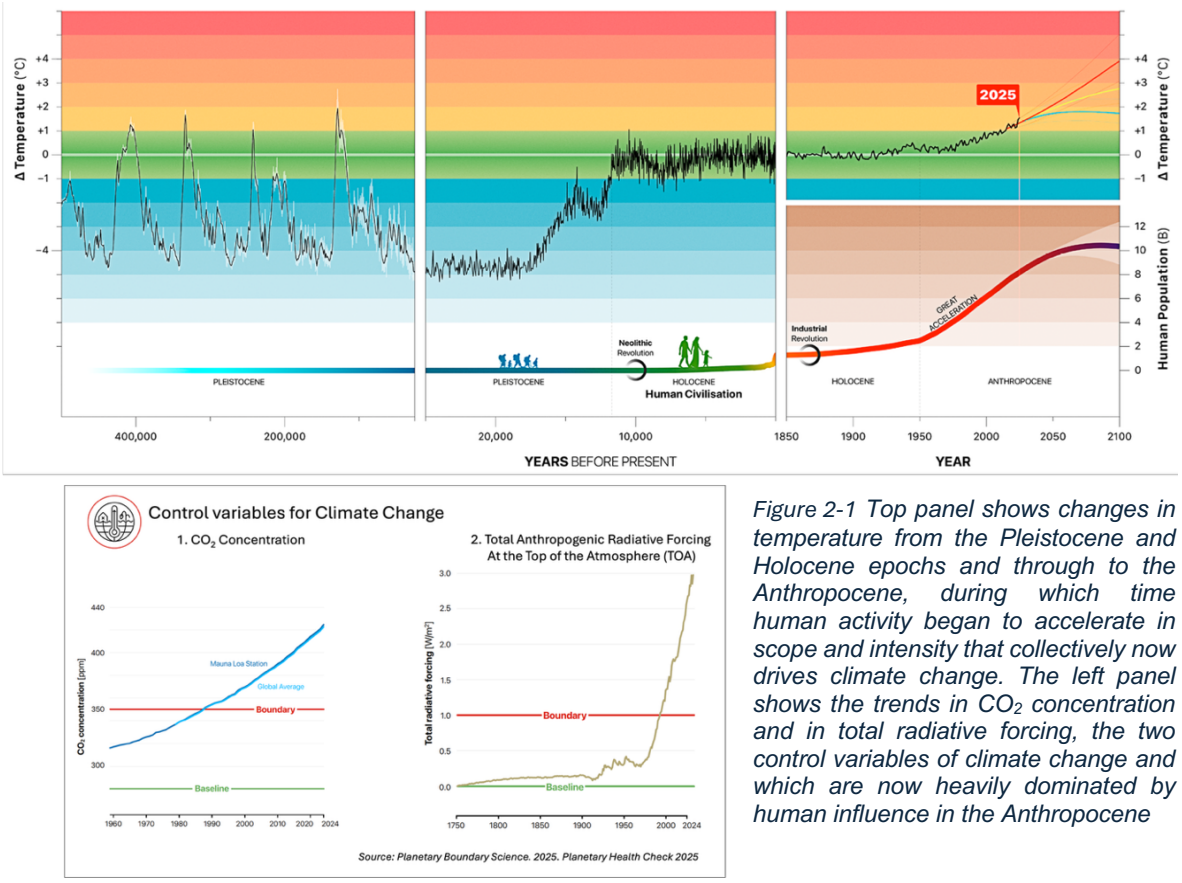


Figure 2-1 Top panel shows changes in temperature from the Pleistocene and Holocene epochs and through to the Anthropocene, during which time human activity began to accelerate in scope and intensity that collectively now drives climate change. The left panel shows the trends in CO_2 concentration and in total radiative forcing, the two control variables of climate change and which are now heavily dominated by human influence in the Anthropocene

Two control variables can be used to track climate change. Carbon dioxide concentration is shown in Figure 2.1 (lower left panel) to have crossed a boundary of 350 ppm, proposed by scientists using paleoclimate evidence (180-200 ppm during ice ages and about 280 ppm before the Industrial Revolution). It continues to rise over the period since post-WWII and is expected to reach 427.5 ppm in 2025, or 52% above pre-industrial levels (Friedlingstein et al. 2025).

The second climate change control variable is the net radiative forcing (Figure 2.1, lower right). It measures the amount of heat energy that is added to the earth system because of greenhouse gas emissions, aerosols and those emanating from land-use changes like deforestation, increase in area of built-up surfaces, and of croplands and pasturelands that contribute to gaseous emissions. Before the advent of the Industrial Revolution, the net heat balance was stable over most of the Holocene Epoch, in the last 11,700 years, during which human societies shifted from being hunter-gatherers to pioneering farmers that staged the First Agricultural Revolution. A total anthropogenic radiative forcing at +1.0 W/m^2 is proposed as a limit because of growing evidence that polar ice sheets begin to respond to warming above +1.5 W/m^2, a major trigger that will alter both the freshwater and salinity balances that determine the strength of oceanic circulation in distributing heat around a water planet. Like CO_2, the net radiative forcing has exceeded the boundary at the beginning of the millennium and continues to increase. Officially, we remain in the Holocene Epoch, because the use of the term "Anthropocene" has been denied by the International Stratigraphic Commission as the Epoch succeeding the Holocene (Steffen et al. 2016, Waters and Turner 2022, McCarthy et al. 2025, Skelton and Noone 2025). Unofficially and recognizing the strength of presented evidence, the Anthropocene may be informally called a geologic event.

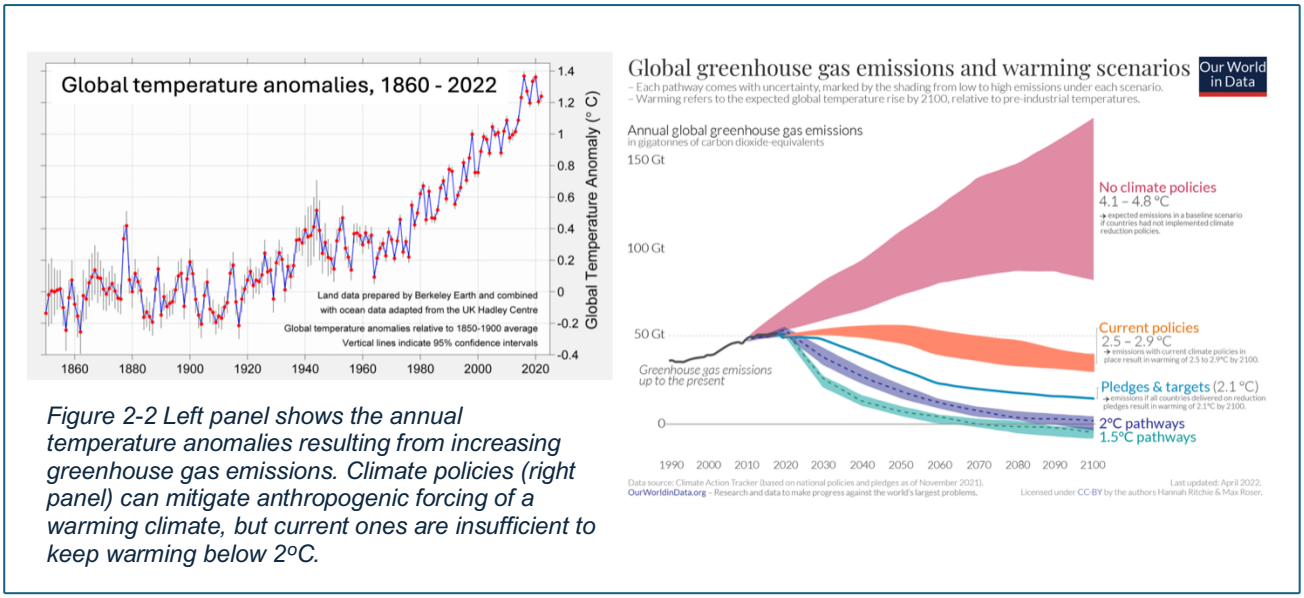


Figure 2-2 Left panel shows the annual temperature anomalies resulting from increasing greenhouse gas emissions. Climate policies (right panel) can mitigate anthropogenic forcing of a warming climate, but current ones are insufficient to keep warming below 2°C.

Figure 2.2 above shows the resulting warming of the earth (average differences between land and sea surface temperatures), and relative to the period 1860-1890, the period of the Industrial Revolution. In 2024, the global temperature difference between land and sea surface reached 1.36°C (Friedlingstein et al. 2025). Limiting warming to 1.5°C is now nearly impossible. With 50 GtC as limit, only 170 GtCO_2 can be emitted, and at 2025 emission rates, the time it will take to reach this CO_2 concentration limit translates to 4 years!

If one examines how to strategically limit greenhouse gas emissions, the evidence is clear. Figure 2.3 shows that in 2016, a fossil fuel-based economy contributed the lion share at 73% of GHG emissions including those from manufacturing (24%), from energy usage by buildings (18%) and transport (16%). Deforestation and agriculture, as well as other land use conversions, initially contributed as much as 30%, but the aggregate of these factors known collectively as Land Use-Land Use Change, has steadily decreased. Transforming energy sources to renewables including the infrastructure to enable the rapid adoption of these may be among the most consequential collective action that humanity can take to save itself and the planet.

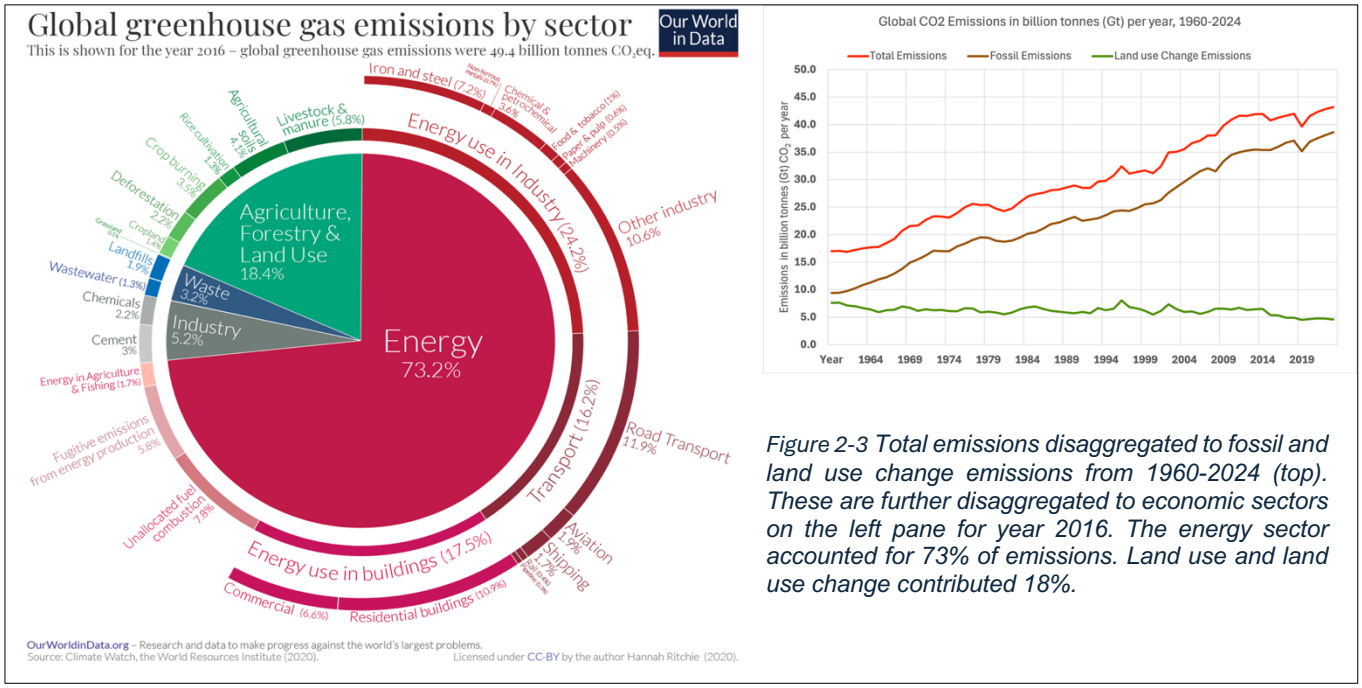


Figure 2-3 Total emissions disaggregated to fossil and land use change emissions from 1960-2024 (top). These are further disaggregated to economic sectors on the left pane for year 2016. The energy sector accounted for 73% of emissions. Land use and land use change contributed 18%.

2.2. How much do SCS-GoT coastal states contribute to climate change?

Greenhouse gas emissions. One way to examine CO_2 emissions among countries is to use an annual per capita emission rate which divides country emissions by their respective population sizes. Though mostly a statistical construct for consumption by an average individual in one's country and is used to remove the effect of a country/ territory area or associated population sizes in comparing emissions globally, individual consumption patterns that define the extent of individual rates of greenhouse gas emissions, are determined by one's choices and socioeconomic conditions and can vary greatly from one household to another in the same country. Global per capita rate for 2024 was 4.73 tons per year (Figure 2.4). Singapore (9.24 tons per year), China (8.66 tons per year) and Malaysia (8.16 tons per year) exceeded this global per capita average. Thailand (3.74 tons per year) and Viet Nam (3.67 tons per year) were slightly below the global average. Indonesia was at 2.87 tons annually. Residents of the Philippines (1.51 tons annually) and Cambodia (1.24 tons per year), on average, emitted the least among SCS-GoT coastal states, on an annual per capita rate.

Another way to examine GHG contributions is at country scale. The SCS-GoT coastal states, less China, accounted for 6.8% of global CO_2 emissions in 2024 (Figure 2.5). China contributed 27.7% of total global emissions that have reached 43.18 billion tons. Adding emissions from Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam with those from China, the littoral countries of SCS-GoT, populated with 25% of humanity living on 9% of earth's land mass (less China becomes 2.4%), emitted more than a third (34.5%) of global emissions in 2024.

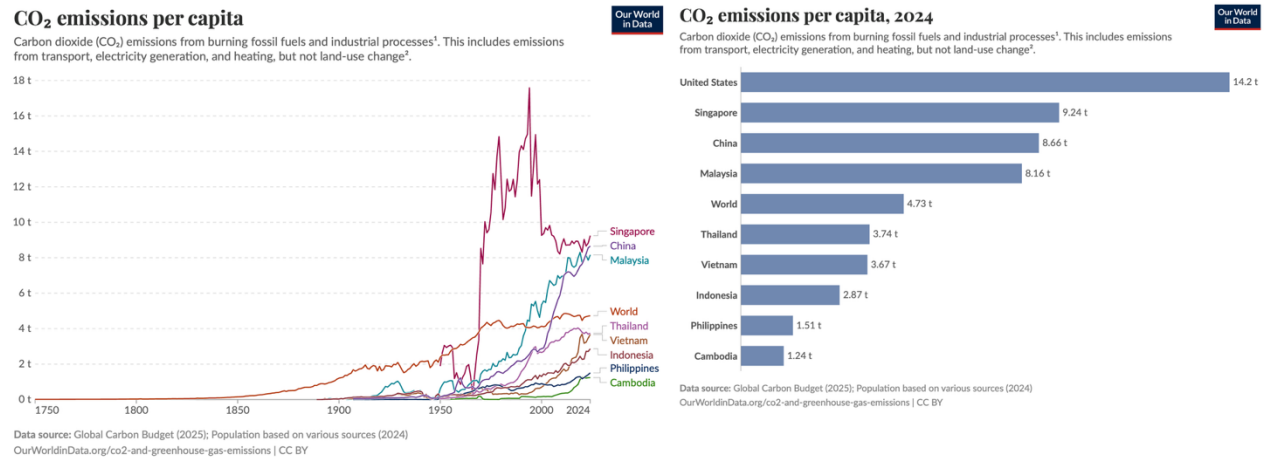


Figure 2-4 CO_2 emissions per capita include emissions from fossil fuels, industrial use, transport, electricity generation and heating, and does not include land use change. Among SCS-GoT coastal countries, Singapore (2X), China (1.8X) and Malaysia (1.7X) emitted greater than the global per capita rate of 4.73 tons CO_2 per year.

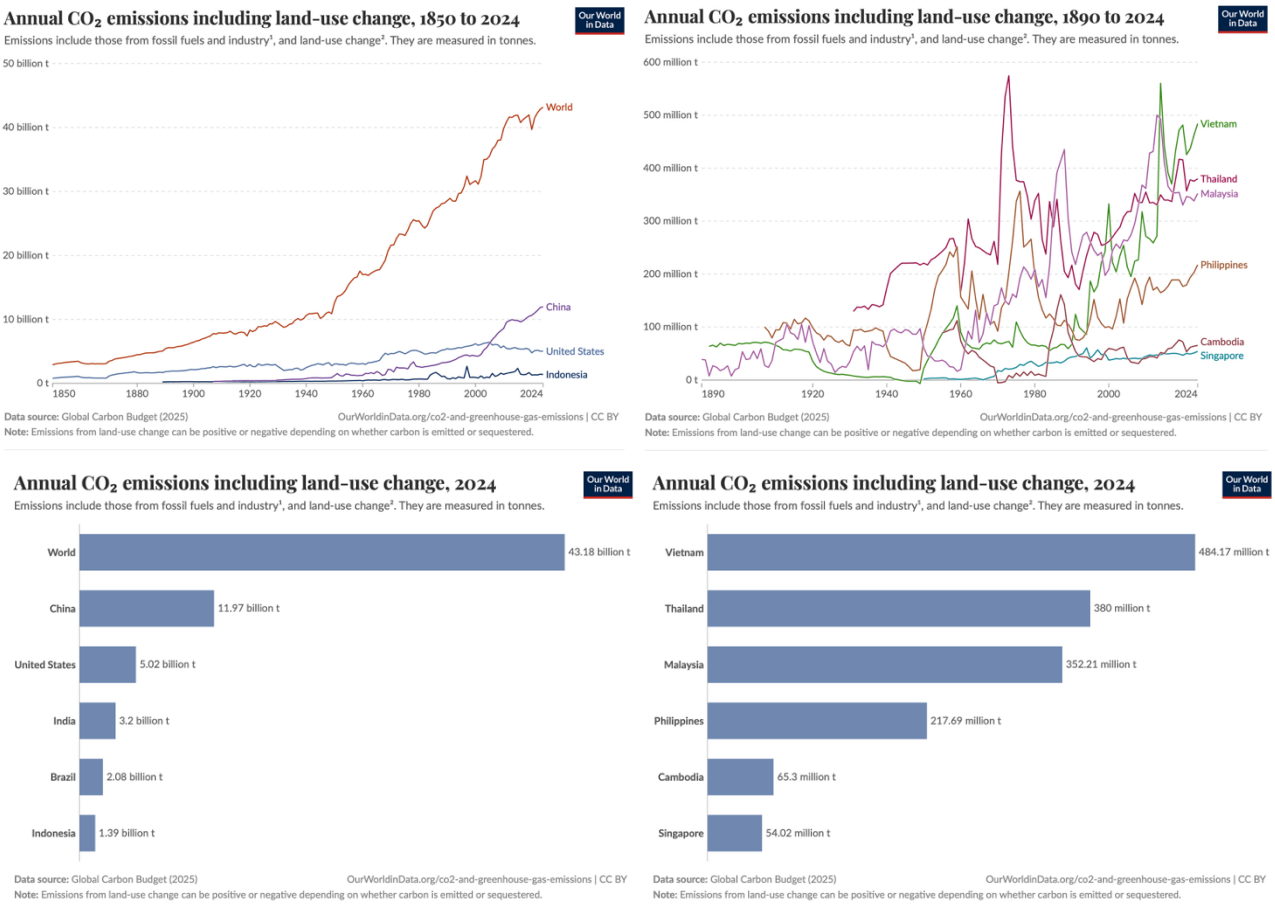


Figure 2-5 Top line graphs show the annual CO_2 emissions from China, Indonesia, Vietnam, Thailand, Malaysia, Philippines, Cambodia and Singapore in the order of highest to lowest contributing SCS-GoT country. Bottom bar charts indicate contributions in 2024. SCS countries exclusive of China accounted for 7% of global emissions. China alone accounted for 28% in 2024.

Land use change and GHG emissions. Among Southeast Asian nations and China, the issue of land use change, (e.g. the modification of natural landscapes such as forests to farmland, or mangrove stands to aquaculture ponds), playing a major role in carbon emissions, is of crucial importance. Finely resolved data sets and higher computational capacities across several disciplines in the last five years, have provided a deeper understanding of climate processes, their interactions, and potential areas of strategic mitigation towards achieving climate neutrality.

Figure 2.6 shows the chronology of land use change from 1850 to 2024 (Global Carbon Budget 2025 and visualized by Our World In Data). In 1850, land use change contributed a staggering 93% of global CO_2 emissions estimated to be 2.9 Gt CO_2. Seventy-four years later (2024), land use change accounted for only 11% of global emissions which has increased 15-fold to 43.2 Gt CO_2.

In the context of SCS-GoT states, the changes have been quite dramatic (Friedlingstein et al. 2025, Sasmita et al. 2025, Fang et al. 2025). Indonesia took over China as the dominant source for Land Use Change GHG emissions in the 1980s when China began its large-scale afforestation (Fang et al. 2025). Subsequently China reversed its carbon budget for land use change from a net source to net land sink (Figure 2.7). Large-scale forestry programmes continued to be implemented for the period 1998 to 2019, and which further enhanced the absorption capacity of forested land to sequester, not release, carbon.

Over the period 2001 and 2022, Southeast Asia lost about 41% of its peat swamp forests (PSFs) and 7.4% of its mangroves (Sasmita et al. 2025). PSFs were converted into tree and oil palm plantations, and mangrove stands were cleared to build aquaculture ponds, producing mangrove wood chips as derived products. PSFs accounted for 98% of emissions because of their higher carbon density and greater deforestation rates compared to mangroves. PSFs emissions came largely from peat decomposition (46%), deforestation (23%), peat burning (20%) and drainage canal construction (9%). Annual emissions from peat fires were variable but peaked during El Niño and Indian Ocean Dipole Dry Phases such as events in 2006 and 2015. Four countries in the region emitted 90% of land use-sourced GH gases: Indonesia (73%), Malaysia (14%), Myanmar (7%) and Vietnam (2%). Sasmita et al. (2025), most importantly, examined potential mitigation strategies. One, the conservation of existing PSFs and mangroves confers significantly higher benefits than secondary regrowth, which can absorb only 2.3% of annual emissions. The most effective strategies include rehydration of drained peatlands, which is more effective at 66% of mitigation potential than revegetation (Table 2.1). The use of nature-based solutions to offset emissions from land-use change to meet sizable portions of national emission targets is most significant for Malaysia at 88%, Indonesia at 64%, and the Philippines at 26%, among the SCS-GoT coastal countries.

Regional contribution to global warming. Total GHG emissions translates to warming contributions from countries to heat up planet earth to 1.68 ºC for the period from 1851 to 2024. On aggregate, SCS-GoT countries contributed 20% of global mean surface temperature increase in 2024, with China imparting 13% and the rest contributing 7%, half (3.5%) of which was heat emanating from Indonesia (Figure 2.8).

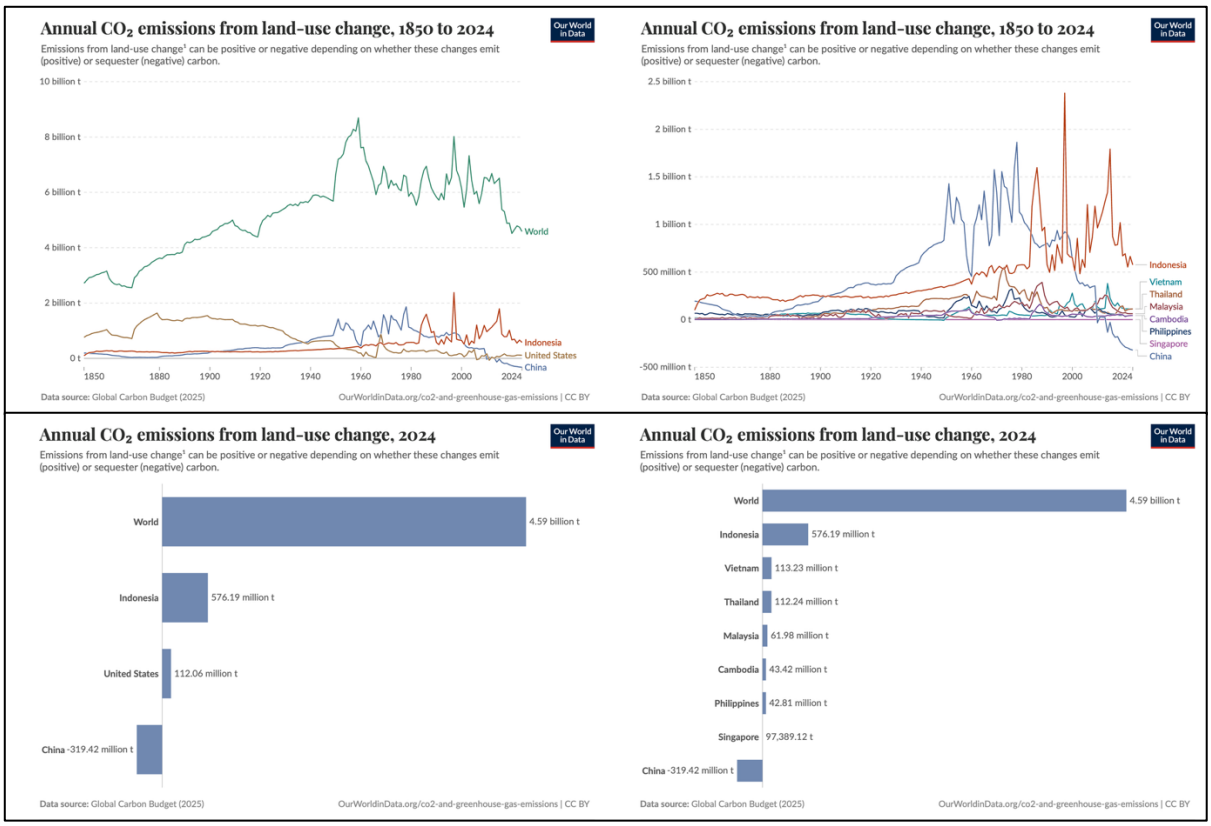


Figure 2-6 Contribution of Land use change to annual emissions for the period 1850 to 2024 (top line graphs) and for year 2024 (bottom bar graphs).

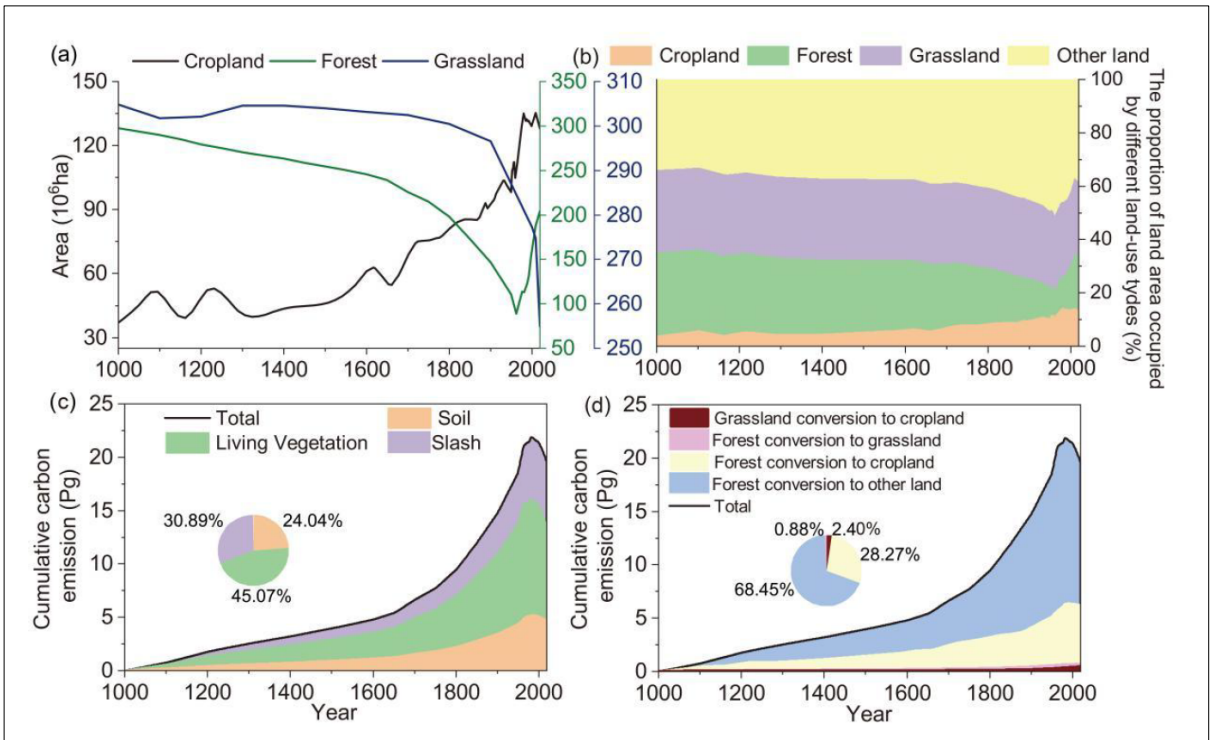


Figure 2-7 Land use changes in China for the period 1000 – 2019 assessed by Yang et al. (2025) using millennial data set of millennial land use change at provincial level and comprehensive soil and vegetation carbon data sets. Large scale afforestation from 1980 to 1998 and large-scale forestry programmes from 1998 to 2019, not only reversed land use carbon balance from source to sink, but further enhanced the land sink function.

Table 2-1 Average loss of peat swamp forests (PSFs) and mangrove in Southeast Asia including their associated carbon emissions and potential to mitigate national Forest and Land Use Change (FOLUC) emissions (Sasmita et al. 2025).

Country	PSFs loss	Mangrove loss	Carbon emissions	Carbon removals by natural regrowth[a]	Emissions reduction potential by restoration	Total mitigation potentials	LUC emissions	Total mitigation potentials proportion to LUC emissions
	ha year^{-1}, 2001–2022		Tg CO_2e year^{-1}, 2001–2022		Tg CO_2e year^{-1}			%
Indonesia	190,617	9459	504.7 ± 95.4	−13.52 ± 2.00	76.74 ± 7.30	567.9 ± 95.7	888 ± 50	64
Malaysia	42,593	3336	96.4 ± 8.5	−1.33 ± 0.13	15.40 ± 1.25	110.5 ± 8.6	126 ± 10	88
Myanmar	2450	1887	50.6 ± 15.3	−0.59 ± 0.10	0.62 ± 0.14	50.6 ± 15.3	130 ± 4	39
Philippines	2102	534	13.3 ± 4.0	−0.05 ± 0.00	0.25 ± 0.02	13.8 ± 4.1	50 ± 5	13
Viet Nam	605	275	12.3 ± 4.3	−0.24 ± 0.03	0.89 ± 0.14	12.9 ± 4.3	106 ± 8	26
Cambodia	561	223	5.4 ± 1.7	−0.07 ± 0.04	0.14 ± 0.02	5.5 ± 1.7	30 ± 2	18
Thailand	252	479	4.8 ± 1.4	−0.086 ± 0.003	0.20 ± 0.02	5.0 ± 1.4	50 ± 9	10
Laos	422	-	3.4 ± 0.7	−0.014 ± 0.003	0.08 ± 0.02	3.5 ± 0.7	38 ± 2	9
Brunei Darussalam	122	10	0.6170 ± 0.2153	−0.025 ± 0.003	0.14 ± 0.003	0.7 ± 0.2	1.2 ± 0.1	60
Singapore	-	3	0.0014 ± 0.0002	−0 ± 0	0.0006 ± 0.0004	0.0021 ± 0.0005	0.1 ± 0.01	2
Timor Leste	-	1	0.0008 ± 0.0001	−0 ± 0	0.0004 ± 0.0002	0.0012 ± 0.0002	2.7 ± 0.2	0.04
SEA	239,723	16,387	691.8 ± 97.2	−16.32 ± 2.01	94.4 ± 7.4	770.3 ± 97.5	1422 ± 54	54

Total mitigation potentials are the summary product of emissions, removals, and emissions reduction potentials of carbon according to an optimal restoration scenario. Land-use change emissions represent country- and regional-level annual emissions between 2001 and 2022 obtained from ref. 83.
[a]Negative value indicates carbon removals generated by enhanced biomass carbon stocks following natural regrowth. CO_2e values are presented as mean ± 95% confidence interval.

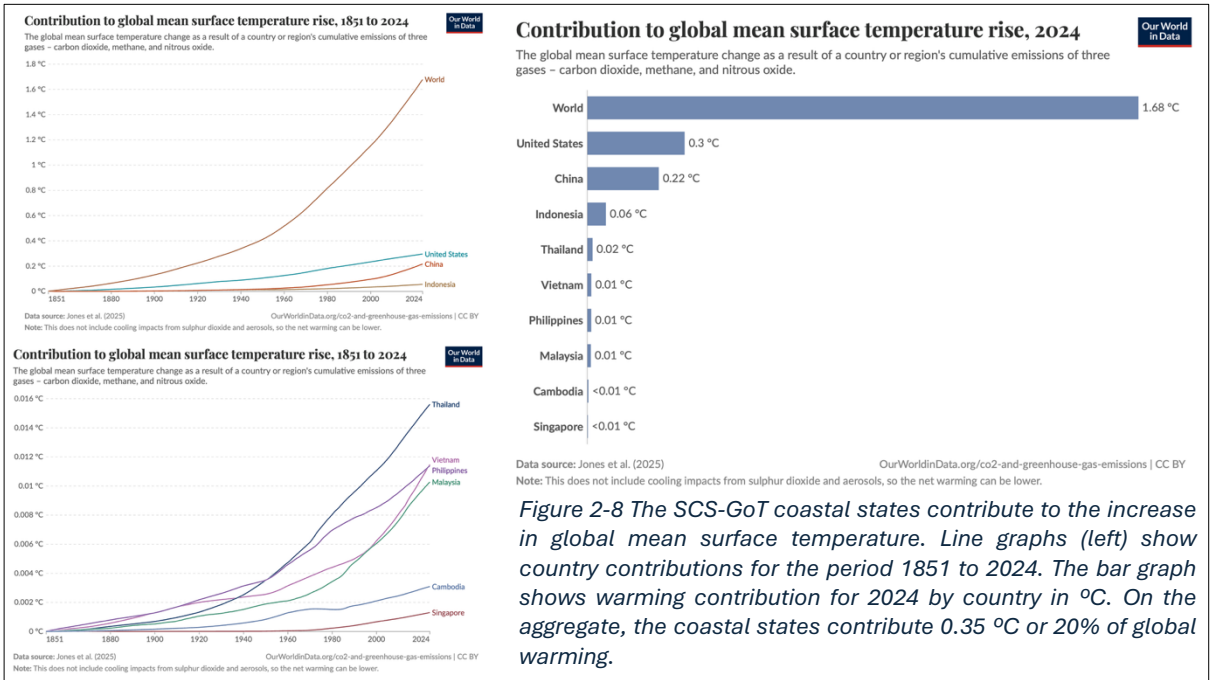


Figure 2-8 The SCS-GoT coastal states contribute to the increase in global mean surface temperature. Line graphs (left) show country contributions for the period 1851 to 2024. The bar graph shows warming contribution for 2024 by country in ºC. On the aggregate, the coastal states contribute 0.35 ºC or 20% of global warming.

2.3. What physical risks do SCS-GoT countries face because of climate change?

Biodiversity at stake. The role of coastal states fringing the SCS-GoT as emitters of GHG and contributors of heat for a rapidly warming climate is insufficiently understood without considering their unique geography. The Indo-Pacific (IP) Region (Figure 2.9), a vast biogeographic region that includes the waters of the Indian Ocean and those of the West and Central Pacific Ocean is the geography to situate climate processes that are relevant to SCS-GoT LMEs and surrounding countries. It subsumes 40 economies, such as those of Southeast Asian nations, Australia, India, Japan and South Korea. An IP subregion, the Maritime Continent is made up of the archipelagoes of Indonesia, the Philippines, and Papua New Guinea, the Pacific Islands and many territorial seas. It overlaps with the Coral Triangle, with the addition of the Far Southwestern Pacific Region, to make up the center of global marine biodiversity, and which is

inclusive of the South China Sea (Figure 2.9.) (See Section 5 for climate impacts on marine ecosystems). The atmosphere above the IP Region has three overlapping climate circulations – the Monsoon, Hadley and Walker Circulation, making the Indo-Pacific Region the most dynamic for ocean-land-atmosphere (OLA) energy transfers on the planet. As such, it is among the most consequential of geographies in tectonic history, climate interactions, and biosphere-scale processes such as species evolution and their biogeographic distributions.

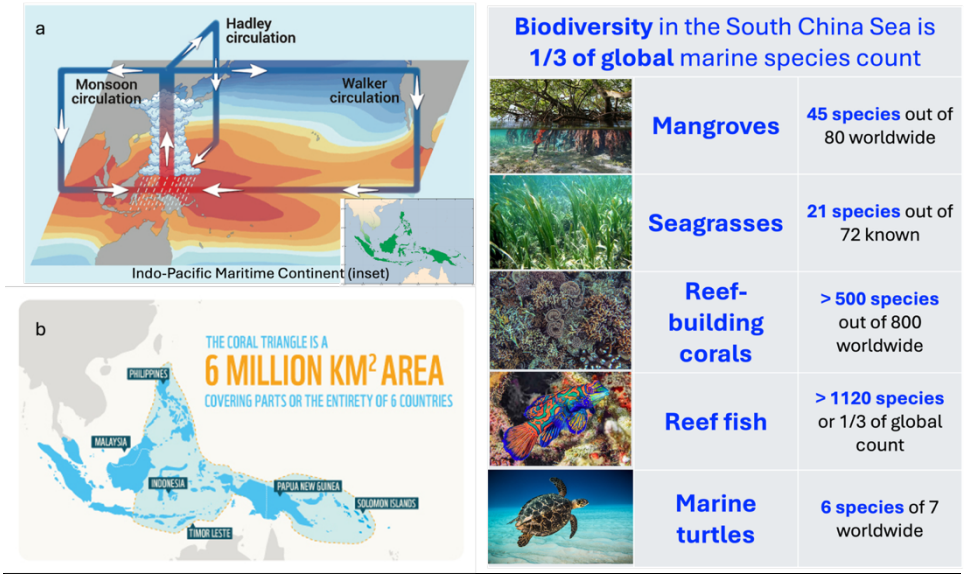


Figure 2-9 Spatial scales for describing climate change: a) Three atmospheric systems – Monsoon (East Asia), Hadley and Walker Circulations overlap above the Indo-Pacific Maritime Continent (inset), surrounded by the Indo-West Pacific Oceanic Warm Pool, the heat engine of the globe. The Maritime Continent overlaps with the Coral Triangle, the global center of shallow-water marine biodiversity and fringes the South China Sea to the east.

Indo-Pacific Oceanic Warm Pool Interactions Determines Global Climate Patterns. In the ocean, the most critical climate component situated in the Indo-Pacific Region is the Indo-Pacific Oceanic Warm Pool (IP-WP). The OWP is the largest oceanic region where sea surface temperatures remain above 28°C throughout the year stimulating atmospheric deep convection, creating water vapor and rain in the overlying tropical air masses (Figure 2.9a). The convective potential of the IP-Warm Pool influences the atmospheric circulation cells (Pacific Walker, Monsoonal, and Hadley) as well as with coupled ocean-atmospheric oscillations such as the Madden-Julian Oscillation (30–60-day duration) and the El Niño Southern Oscillation (occurring every 3-7 years). Such interactions impact rainfall distribution, duration and intensity; the frequency and intensity of extreme temperature and marine heatwave events; as well as the occurrence and intensity of tropical cyclones. As such the behavior of the IP-Warm Pool in shaping both weather and climate patterns in a regime of rapid climate change, defines and constrains the quality of human wellbeing and the ecosystem health in the IP-Region, including the SCS-GoT countries and the world, in fundamental ways. Governance at all levels would need to be more than proactive in curbing anthropogenic drivers of climate change. Climate-informed development planning is foundational to increasing climate resilience of citizens and ecosystems alike.

Physical vulnerability of SCS-GoT countries to climate change. The Indo-Pacific Region is ground zero for climate change. To capture policy-independent and policy-dependent sources of vulnerability, the regional transboundary analyses used two indices: the Physical Vulnerability to Climate Change Index (PVCCI) (Goujon et al. 2022, 2024) for policy-independent vulnerability measure, and the Multidimensional Vulnerability Index (MVI) (Guillamont and Wagner (UN 2021) which contains metrics that address both types of vulnerability sources. In this section, PVCCI

for SCS-GoT countries are presented, and the MVI that integrates physical, social and economic dimensions of vulnerability are discussed in Section 3. Physical vulnerabilities are best addressed as deliberate actions towards adaptation, as opposed to socioeconomic vulnerabilities that require policy choices to address unjust access to social benefits. Adaptation refers to measures that protect against extreme weather, currently and in the future (Krishnan et al. 2025). Adaptation strategies must be addressed as failure to do so amplifies socioeconomic risks.

The PVCCI is an index that subsumes both exposure and hazards to five natural climate variables: two slow-onset hazards (flooding and aridity) and three fast-onset hazards (temperature extremes, rainfall, and cyclones). The metric for flooding includes flooding due to sea level rise or melting glaciers. Input data are purely geophysical variables for precipitation, temperature and potential evapotranspiration cover the period from 1950 to 2021; storm frequency and intensity data are from 1970 to 2014; and glacier data are current to 2017. The PVCCI has been computed for 191 countries at both country and subnational scales, with values ranging between 0 < PVCCI < 100 and expressed as percentages. Low PVCCI values indicate low vulnerability, and high values mean high vulnerability. The results for SCS-GoT countries based on national scale indices are shown in Figure 2.10, in comparison with the rest of the world, and zoomed in for regional cross-country comparisons for each hazard.

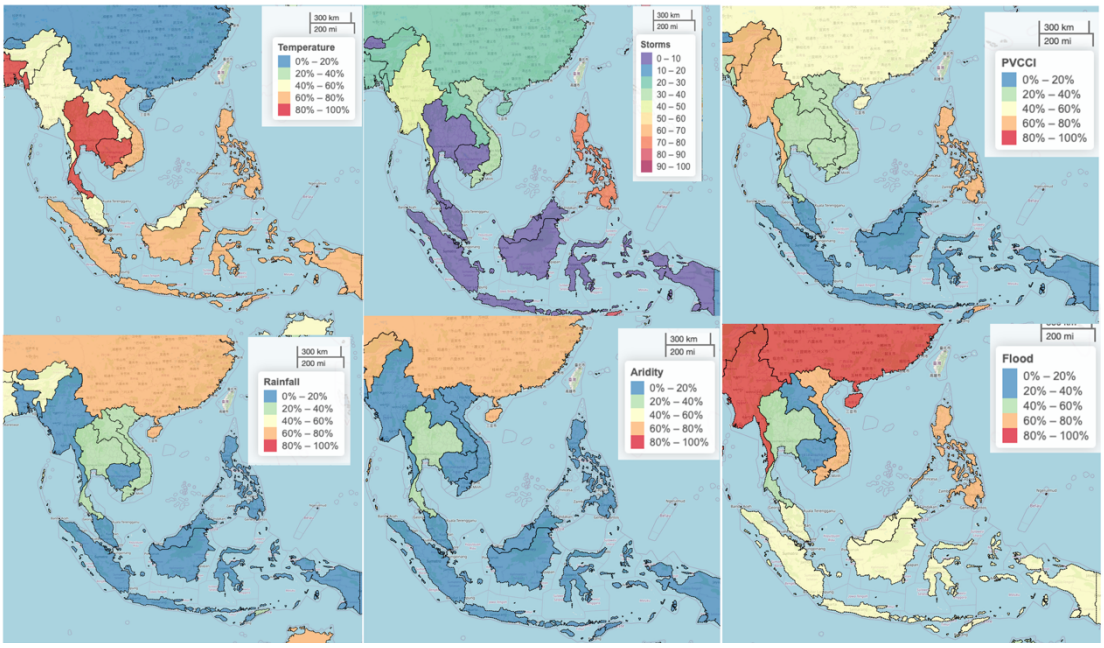


Figure 2-10 Physical Vulnerability to Climate Change Index for SCS-GoT coastal countries by individual climate hazard, and by overall PVCCI Index (top right panel). Higher values indicate higher vulnerability, and lower values mean lower vulnerability (Goujon et al. 2024).

When PVCCI values are computed at national scale, the order of regional vulnerability ranking was Philippines (53.94) > China (50.28) > Thailand (47.86) > Cambodia (47.86) > Viet Nam (46.13) > Singapore (45.61) > Indonesia (42.22) > Malaysia (41.13).

To examine more closely the risks that the top two countries face, subnational indices calibrated with population density for Philippines and China, were mapped. Figure 2.11 shows the Philippines and China exchanging places with the latter becoming the more vulnerable country to purely geophysical hazards. These physical vulnerability indices are only as good as the underpinning data which are historical. Physical vulnerability indices based on future scenarios

are needed to examine and enhance capacities for longer-term climate-informed resilience and adaptation development planning.

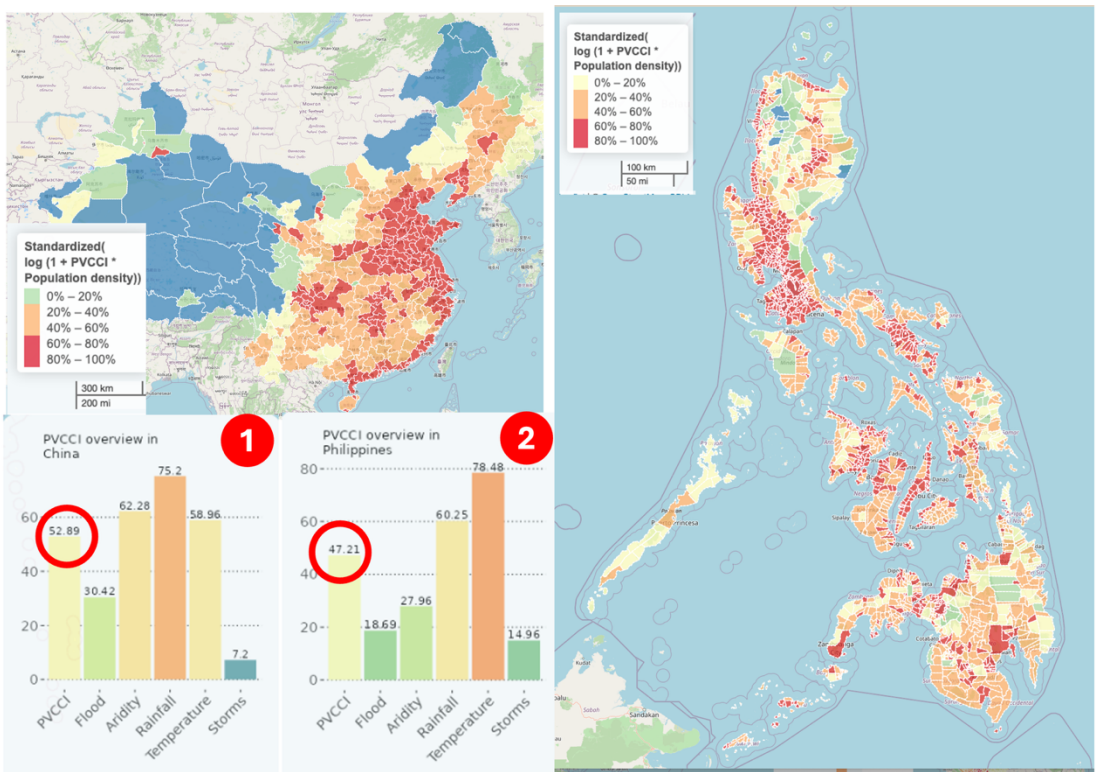
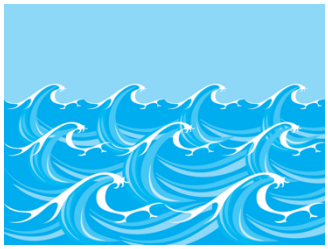


Figure 2-11 The top two most vulnerable countries based on PVCCI computed at subnational levels and calibrated by population density are China followed by the Philippines. China is most physically vulnerable to rainfall, aridity and temperature extremes. The Philippines is vulnerable to all five geohazards and is most vulnerable to storms among all SCS-GoT coastal states (see also Figure 2.10).

Climate projections for SCS-GoT countries to 2050. Norris et al. (2024) provide projections to 2050 for regional climate patterns for Southeast Asia, the northern part of which is applicable to Southern China (Table 2.2). Except for China, most countries in Southeast Asia do not have sufficient observation records to allow for more highly resolved modeling and climate attribution (i.e. attributing the occurrence of extreme weather events to anthropogenic climate change). Plausible outcomes under low-emission and high-emission scenarios are summarized in Table 2.2 and the socioeconomic risks these impose are further explored in Section 3.

Table 2-2 Future climate projections to 2050 for Southeast Asia including Southern China (Norris et al. 2024).

Climate Variable	Projections to 2050
Average temperature 	• Average temperatures will increase uniformly by around 1.1ºC by the 2050s under a medium emission scenario compared to a 1981-2010 baseline, with increases of up to 3.5 ºC possible under high emission scenarios. • Under high emission scenarios, regional variation may be expected with highest warming projected to occur across Thailand, northern Lao PDR and southern Myanmar. • The intensity, number and duration of positive heat extremes will increase in the region. • Moist (typical) heatwaves are likely to be an increasing hazard through Maritime Southeast Asia (Indonesia, Philippines, Malaysia, Singapore).
Average rainfall 	• Annual rainfall is projected to increase across the region and is most pronounced in northern Thailand through the southwest monsoon season (June to October). Some projections indicate a drying trend in southern Indonesia outside of the main wet season (April to October). • The frequency of intense rainfall events is expected to increase across the region. • The number of consecutive dry days are projected to increase across Maritime Southeast Asia by 5-15 days per year by the 2050s. • The proportion of intense typhoons (those of Category 3-5) will increase
Sea variables: ● Sea surface temperature ● Sea level rise ● Marine heatwaves 	• Sea surface temperatures in the region will increase by 0.7 ºC on average by the 2050s under a low emission scenario and by 1.2 ºC under a high emission scenario, relative to 1995-2014 baseline. • Sea levels across the region will continue to rise through the 2050s and beyond. By the 2050s, sea level will rise by 0.2-0.3 m irrespective of emission scenario, compared to a 1995-2014 baseline. • South China Sea and the Gulf of Thailand will continue to acidify, and the frequency, intensity and duration of marine heatwaves will increase.

Climate icons from vecteezy.com

2.4. How can SCS-GoT countries adapt to present and future physical hazards of climate change?

Adaptation steps are measures that protect against present and future extreme weather. In a conventional transboundary diagnostic analysis, these are considered beyond the purview of the environmental scientists who have led the TDA. The incorporation of these measures in this report aims to inform policy makers that an integrated view of contemporaneous transboundary environmental problems and socioeconomic impacts these create cannot be dissociated from issues of climate change. Adaptation minimizes risk by reducing vulnerability or exposure. However, there are soft and hard limits to adaptation. Lack of financing and political will are considered soft limits. Severity of extreme weather events can present as hard limits when these overwhelm adaptation. Hard limits include a 1.5ºC degree warming that results in freshwater shortages for small islands; and a 2ºC temperature increase that leads to extensive coral bleaching. Adaptation spans the gamut of adopting behavioral, digital, engineering, and nature-

based solutions to achieve protection, and is often evaluated through cost-benefit analysis. The net benefits are in the form of avoided damages, in addition to co-benefits that may not be fully accounted for. Also, like any emerging technology, adaptation measures to address one problem can generate maladaptation in another especially when trade-offs are not properly or are unjustly weighted.

The following list shows examples of adaptation measures (World Resources Institute 2025, Krishnan et al 2025, Feng et al. 2025) and which can also at the same time mitigate climate change by lowering or removing GHG emissions. While this list focuses on adaptation to lessen vulnerability to physical hazards, integrating these to effectively lessen socioeconomic risks and to guide development plans towards sustained resilience may have become the contemporaneous grand challenge for governance of the 21st century.

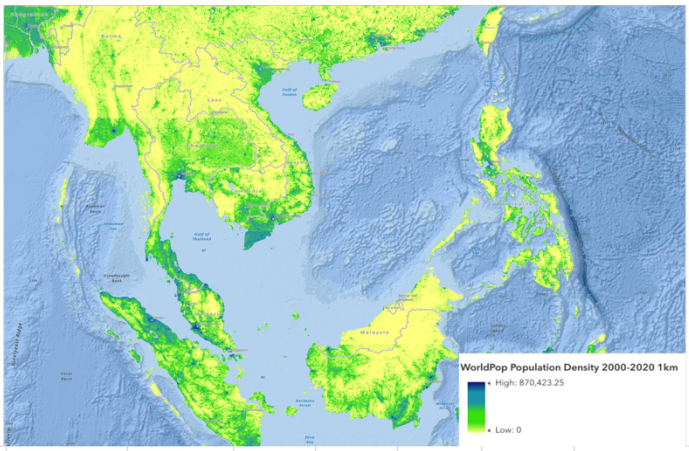
Table 2.3 Examples of adaptation measures to minimize physical vulnerability to climate change-induced geophysical hazards. Menu of measures obtained from cited sources (WRI 2025, Krishnan et al. 2025, Feng et al. 2025).

Geophysical Hazard	Adaptation measure	How measure works
All	Establish integrated Early warning systems (EWS) including community preparedness	These monitor and forecast weather for extreme events. These are relayed to weather stations to provide guidance to exposed populations including evacuation and shelter locations. Community preparedness including public services need to go together to optimize benefits. Benefit-to-cost ratio: 10+ (Krishnan et al. 2025)
All	Expand decentralized renewable energy	Decentralized grids powered by renewables, and some at scale of community-based grids, can lessen vulnerability and enhance adoption of renewable technology. These include solar panels and wind turbines which can provide reliable, clean energy, which are critical especially in the aftermath of extreme weather events (WRI 2025)
All	Promote sustainable agriculture and land use	Measures such as agroforestry, rotational cropping, silvopasture, and community-managed forests can increase farmers' resilience to climate change impacts while at the same time reduce land use emissions, which accounts for 20% of GHG emissions.
All, Heat	Invest in climate-smart buildings	Smart design including passive cooling, white-painted rooftops, and use of lower carbon materials to reduce heating/ cooling costs. Note that this also provides co-benefits in the reduction of emissions. Buildings account for 20% of GHG emissions.
Heat	Expand green spaces in urban areas	Expansion of tree canopy and vegetative cover to lower ambient and surface temperatures through shading and enhanced evapotranspiration
Flooding; Coastal defense and carbon sequestration as co-benefits	Protect and restore coastal ecosystems such as mangroves, seagrasses and corals	Defend coasts against floods, storm surges and floodwaters. They sequester carbon and are engines of biomass production that support fisheries for many coastal populations. They function as natural water filtration systems and provide nursery habitats for fish and invertebrates.
Flooding	Build stormwater networks	Stormwater drainage systems are networks of underground pipes and storage systems that store and convey stormwater. With sufficient capacity, these provide benefits by protecting against most flood-related damage such as loss of property, infrastructure impacts and economic disruption.
Flooding	Install Detention basins	These are engineered landforms that temporarily hold stormwater runoff, releasing it gradually through soil infiltration or drainage infrastructure. They help reduce the severity of excess-rainfall flooding. Requires substantial land area, and which may not be feasible in dense urban places.
Sea level rise	Use "soft" shoreline maintenance	• Create dunes including planting dune grasses to induce settling of aeolian sands • Increase shoreline setbacks • Plant submerged aquatic vegetation including seagrasses to stabilize sediment and reduce erosion • Remove shoreline hardening structures to allow for shoreline migration • Use natural breakwaters of oysters or other natural breakwaters to dissipate wave action
Sea level rise	Use flexible approaches in planning infrastructure	A dynamic approach to planning infrastructure, instead of one-off construction design for historic 100-year flood projection, for example costs less than other methods, and can more effectively reduce the risk of very bad outcomes (Feng et al 2025)

3. Are people living in coastal countries of the SCS-GoT at risk?

Today, 25% of the global population occupying 9% of the world's land mass reside around the SCS-GoT. The smaller countries of maritime Southeast Asia account for 8% of world population while occupying an aggregate area that is only 2.4% of the earth's total land area. The regional population is rich in history, culture and governance (Section 7) systems, and is called to collaborate on addressing the existential threat of anthropogenic climate change, transboundary pollution (Section 4) and biodiversity loss (Sections 5 and 6). This section summarizes the salient changes in socioeconomic conditions that have occurred in the last 25 years since TDA 1.0, using metrics like those used in TDA 1.0, and examining progress in achieving the goals on social wellbeing in the 2030 Sustainable Development Agenda. It seeks to gauge the socioeconomic risks the littoral states face. As nations are social-ecological systems, social wellbeing is integral to ecosystem health and vice-versa. Effective governance, including environmental, is predicated on a strong and vibrant social capital.

3.1. Demographic features of the region



Country	Population 2025	World Share %	Fert. Rate	Yearly Population Change	Median Age	Urban Pop %
China	1,416,096,094	17.20%	1.02	−0.23%	40.1	67.5%
Indonesia	285,721,236	3.47%	2.1	0.79%	30.4	59.6%
Philippines	116,786,962	1.42%	1.88	0.81%	26.1	49.3%
Vietnam	101,598,527	1.23%	1.88	0.60%	33.4	41.4%
Thailand	71,619,863	0.87%	1.2	−0.07%	40.6	53.5%
Malaysia	35,977,838	0.44%	1.53	1.18%	31	77.4%
Cambodia	17,847,982	0.22%	2.51	1.19%	26.2	26.5%
Singapore	5,870,750	0.07%	0.96	0.66%	36.2	100.0%
Maritime SE Asia	635,423,158	8%	1.89		31.2	54.6%
SCS-GoT	2,051,519,252	25%	1.29		37.3	63.5%

Figure 3-1 Key demographic features of the countries around the SCS-GoT.

From 2000 to 2025, the regional population aggregated among Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam, grew from 1.736 billion to 2.052 billion (Figure 3.1). Fertility rates across all countries of the region are below 2.7, the long-term rate for maintaining human populations from baseline. China and Thailand show yearly annual population changes to be negative, both of which have median ages above 40 years. For maritime Southeast Asia, median age is 31 years. Current population growth has created a pool of relatively young and productive workforce with low dependency by children or elderly. However, the increasing lifespan of the elderly generation may eventually create inverted population pyramids where fewer workers provide for an increasingly growing size of elderly population.

Spatially explicit data on global coastal characteristics enabled this regional analysis to calculate the number of people who live below 5 m elevation along a 4 km wide coast facing the SCS-GoT (Athanasiou et al. 2024). Based on an aggregate population of 2.019 billion in 2020, at least 40 million are at risk in this vulnerable low-lying coastal ribbon. China accounts for 15 million; the Philippines 7.5 million; and Viet Nam, around 6.9 million. On aggregate, around 1.3 billion or 63% of the regional population in 2025 live in urban areas. Four countries – Thailand, Philippines, Viet Nam and Cambodia- show rates below the global urbanization average of 58%. Urban areas concentrate populations over smaller areas, and require provisions for food, water,

energy, and waste (solid and liquid) services to be on par with high population densities, which often overwhelm existing infrastructure and easily exacerbates pollution (See Section 4).

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3.2. Human wellbeing

The region has seen great strides in improving human wellbeing metrics. The Human Development Index (HDI) measures a country's average achievements in three key areas: health (life expectancy), education (mean and expected years of schooling), and standard of living (gross national income per capita). HDI values fall between 0 and 1, with higher values indicating better human development. The Gender Development Index (GDI) is HDI computed separately for female and male populations in a country. A value of 1.0 means gender parity has been achieved; below 1.0 means the female population is disadvantaged, and a value greater than 1.0 indicates the male population is below parity. Figure 3.2 (top middle panel) shows a regional achievement of 0.87 for GDI in 2022; and HDI for women being significantly lower than that for men. The GDI for the region is 13 pts away from SDG 5 for Gender Equality. From 2000 to 2022, the GDI increased 20 points or 1 percentage point per year. To achieve gender parity by 2030, an annual 3-point increase must be achieved for the next five years. For many in the region, a good education is a ticket to better job options, and which opens access to better health services including better nutrition. Educating women, in particular, who can be more informed and prepared in their child-bearing years about making choices regarding family and career, is a good predictor of success based on the same metrics for the generation following (Jackson 2006).

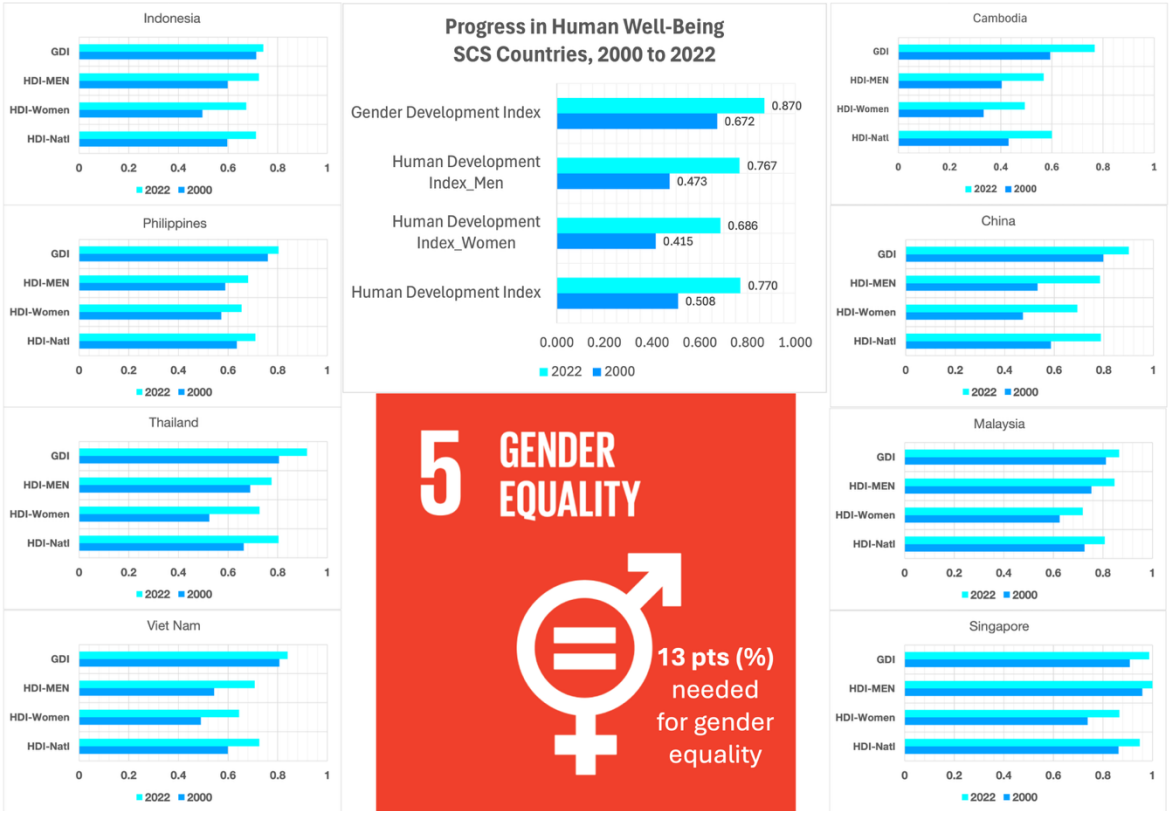
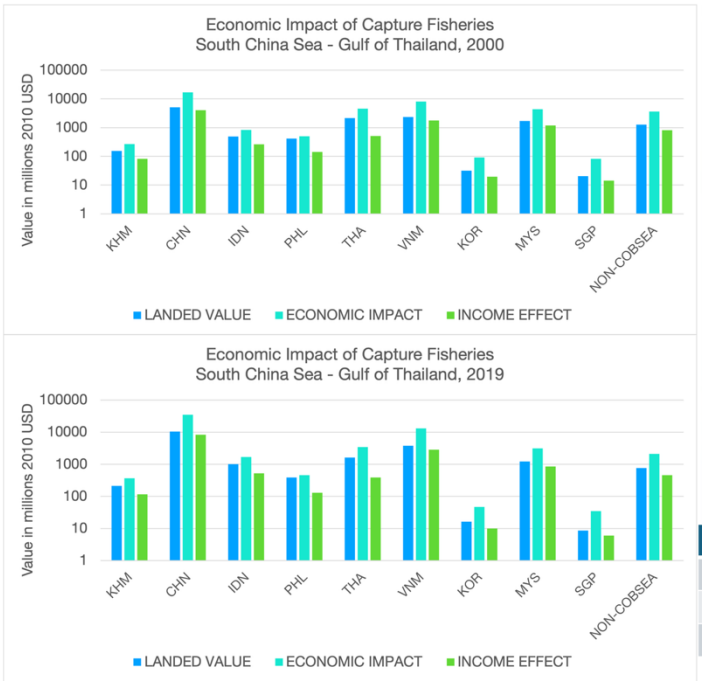
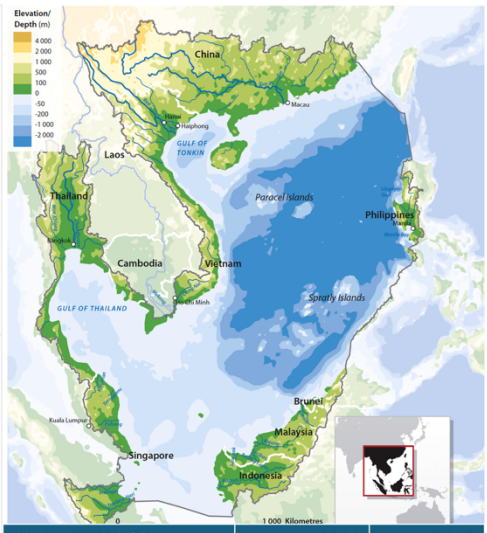


Figure 3-2 Human Development and Gender Development Indices at regional scale (middle panel), and by country. Human Development Index (HDI) values range from 0.0 <HDI <1.0. Gender Development Index (GDI) measures gender equality by comparing female and male achievements in health, education and income. A GDI value of 1.0 indicates gender equality, while values below 1.0 show disadvantages for women, and values above 1.0 indicate disadvantages for men.

3.3. Livelihoods

Fishing and coastal tourism are livelihoods for many coastal residents around the South China Sea and Gulf of Thailand. At least 3 million fishermen are engaged in capture fisheries in these two large marine ecosystems. Section 6 finds the state of the SCS-GoT fisheries to be severely depleted and overexploited (Siriraksophon 2025). In this context, the increases in fishing revenues generated in 2000 and 2019 could only happen when the fishing effort exceeds natural limits. Over the 20-year period, landed value increased by 40%; total economic impact (e.g. boat building, gear supply and repair, fish processing and canneries) jumped 51%, and household income impact was augmented by 51% (Figure 3.3). These increases could not be sustained when fishery resources are severely exploited.





Millions **2010 USD**	**2000**	**2019**
Landed Value	13,600	19,400
Economic Impact	39,200	59,100
Income Effect	9,000	13,600

Figure 3-3 Comparison of landed value, economic impact and income effect of capture fisheries from the South China Sea and Gulf of Thailand for 2000 and 2019, the latest available and internally consistent dataset (SAU 2025).

Tourism in general is a cross-sectoral industry, and a separate travel and tourism satellite accounting must be set up in each country to fully capture the social, economic and ecological impacts of tourism. Specifically, marine-based tourism data are not routinely collected by governments. Data from Spalding et al (2017) determined the value and distribution of coral reef tourism globally and from which values for COBSEA countries were obtained as shown in Table 3.1. About 30% of reef area in SCS-GoT are visited by tourists every year, generating around 2013 USD 9.5 billion annually, or slightly less than 27% of global reef yearly tourism revenues (see also https://maps.oceanwealth.org/#/recreation).

Table 3-1 Tourism values of coral reefs in COBSEA countries (Spalding et al. 2017).

Country	Total reef area (km^2)	Area of reefs used for tourism	Value of coral reefs per year (2013 USD)	Reef visitor expenditures as % Total tourism	Reef tourism as % GDP	Mean value of reef as tourist attraction (2013 USD/ km^2)
Cambodia	116	79 (68%)	$18,070,000	0.87%	0.13%	$157,629
China	351	228 (65%)	$1,435,090,048	0.45%	0.02%	$3,110,617
Indonesia	39,507	9,087 (23%)	$3,054,259,968	7.80%	0.34%	$78,342
Philippines	22,456	7,823 (34%)	$1,354,889,984	8.83%	0.55%	$61,607
Thailand	522	522 (100%)	$2,407,579,904	5.65%	0.61%	$4,619,366
Viet Nam	777	543 (70%)	$136,031,008	1.52%	0.09%	$177,006
Malaysia	2,965	1,816 (61%)	$1,144,220,032	3.36%	0.37%	$391,467

Section 5 highlights that coral reefs are a significant part of a global heritage of biodiversity (Vo 2025). Climate change though can threaten coral reefs. Marine heatwaves trigger reef bleaching events, when the living tissue of corals die from the heat. El Niño years tend to exacerbate the duration of marine heat waves and can cause massive coral die offs as a result, making coral reef tourism vulnerable to climate change, in addition to pollution and overharvest of reef fisheries.

While conventional coral reef tourism provides purely leisure and enjoyment for tourists, perhaps conservation activities can be integrated, including citizen science where data about the health of corals can be gathered by tourists as well. Such data can be used in awareness campaigns. Diving expeditions to sites where heat-resistant species and variants can be found and potentially propagated across affected reefs can become core tourist activities. These actions may help populate reefs recover faster from heatwaves, make tourists more climate-aware and tourist operators more innovative in integrating conservation into their livelihood.

3.4. Poverty and Exposure to Extreme Events

Reducing poverty is the number one priority of the 2015-2030 Sustainable Development Agenda and is a key goal post in gauging progress toward wellbeing. Cuaresma et al. (2018) modeled poverty to 2030 using historical poverty data and made income projections following the demographic and economic assumptions of the Climate Change Shared Socioeconomic Pathway (SSP) scenarios. The regional analysis obtained data for the SCS-GoT countries and applied the poverty thresholds defined by the World Bank based on income classification. Projections for 2020 indicate 413 million impoverished population decreasing to 158 million by 2030 in a Business-As-Usual (SSP2 benchmark) scenario. SSP3 is a pessimistic scenario with significant income inequality and where poverty in 2020 of 437 million decreases more slowly to 237 million. These poverty projections by SSP scenario indicate that zero poverty may not be achievable by 2030 under a business-as-usual or a less egalitarian scenario. If it is to be targeted, a closer examination of poverty shows that it is a human condition that is not just limited by income. The lack of resources is multidimensional and subjects the poor to many risks.

Table 3-2 Poverty estimates following Cuaresma et al. (2018) framework and World Bank poverty thresholds by income classification are sorted. Projections to 2020 and 2030 are used to make regional estimates

2023 GNI per capita threshold 2023 Income classification	SCS Country	Poverty Threshold 2015 PPP USD	2020 Poverty headcounts SSP2- BAU	 SSP3	2030 Poverty headcounts SSP2- BAU	 SSP3
Low-Middle Income US$ 1136-4495	Cambodia	3.2	2,240,212	2,435,946	657,407	1,160,707
	Philippines	3.2	16,055,167	18,240,751	8,820,237	15,782,757
	Vietnam	3.2	18,908,463	20,107,742	8,350,876	11,784,653
Upper-Middle Income US$ 4496-13935	China	5.5	289,016,513	304,634,752	104,956,045	157,359,971
	Indonesia	5.5	74,280,169	77,966,588	29,936,369	42,985,893
	Malaysia	5.5	4,758,876	5,020,826	3,176,416	4,197,233
	Thailand	5.5	7,236,252	7,983,895	1,616,902	3,461,263
High Income US$ >13935	Singapore	5.5	134,093	143,273	89,833	117,111
		Total	412,629,745	436,533,773	157,604,084	236,849,588

Section 2 of the Regional Brief indicated that physical vulnerability to extreme events increases risks to wellbeing and livelihoods. Rentschler et al (2022) examined the extent of flood exposure and poverty in 188 countries. Among SCS-GoT countries, they found that 590 million were at high flood risk (Figure 3.4). Of these, 9 million were living in extreme poverty, subsisting on $1.90 per day; and 26 million and 68 million made do with $3.20 and $5.50 per day, respectively (Table 3.3). Roughly about 1 in 5 (17.4%) of those at high flood risk were impoverished. Among SCS-GoT countries, 42% of those in poverty and at high flood risk live in China, 36% in Indonesia, 14% in the Philippines, 5% in Vietnam, 2% in Cambodia, and 1% in Thailand (Figure 3.4). Disaggregating physical vulnerability to extreme events by level of poverty provides a powerful tool for providing targeted aid, given that safe housing, both in construct and location, may be inaccessible to the disenfranchised to begin with.

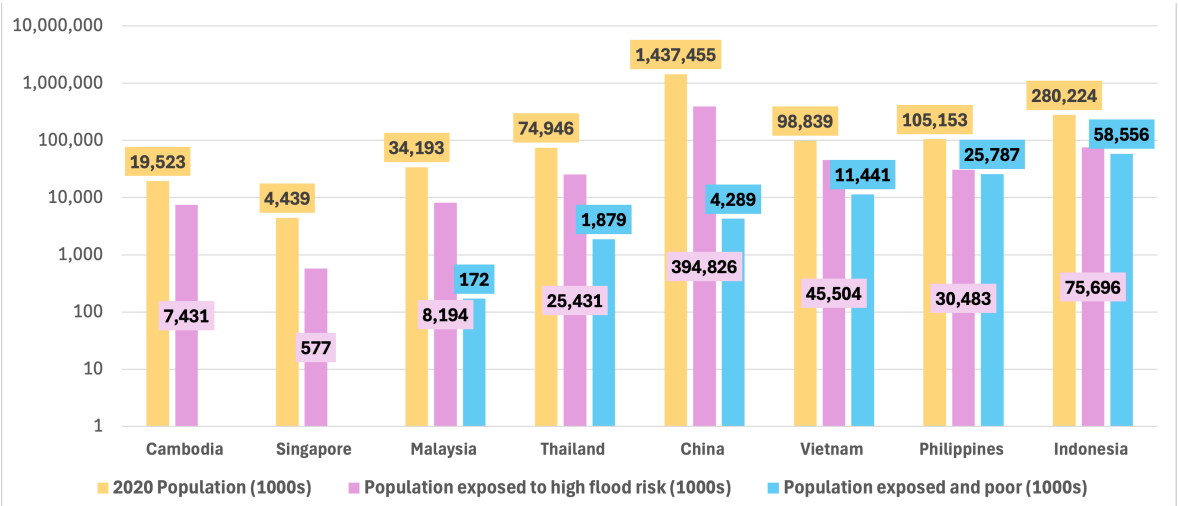


Figure 3-4 Populations of SCS-GoT countries that are exposed to high flood risk and are impoverished. The poor exposed to flood risk is about 102 million, the sum of people with consumption levels at $1.90, $3.20 and $5.50 per day (in thousands). Data are for year 2020 (Rentschler et al. 2022).

3.5. Wellbeing of SCS-GoT coastal populations within the 2030 Agenda for Sustainable Development

The foregoing discussion highlights both the potential to improve wellbeing and mitigate vulnerabilities of coastal populations around the SCS-GoT environs while being subject to climate change. In this section, the framework of the 2030 Sustainable Development Agenda, and progress towards the achievement of 17 sustainable development goals are used as broader context for gauging socio-economic wellbeing in the region.

The Sustainable Development Goal Framework consists of 17 goals, each goal having an associated number of indicators to track quantitative progress toward numerical or aspirational goals. Indicators have equal weights within a goal, and their arithmetic mean yield a goal score. All 17 SD goal scores are used to generate an SDG country index for a data year. Individual indicator and goal scores can be tracked across years to determine progress and status. Among the 17 goals, 9 examine wellbeing at the individual (SDG 1, 2, 3, 4, and 5), household and community scales (6, 7, 8, and 9), 4 examine governance (SDG 10, 11, 16 and 17) and 4 address the environment (SDG 12, 13, 14, and 15) (Table 3.3).

Table 3-3 The 17 Sustainable Development Goals, regrouped into domains of Socio-economics and Governance (13 goals: SDG 1-11, 16, 17)) and Environment (4 goals: SDG 12-15). The International Spillovers Score which gauge transboundary impacts of countries are included in deriving an Environment Index for each country).

Statistical Relationships	Domain	Sustainable Development Goals				
1. Socioeconomic Goal indicators are positively correlated with each other. 2. These were negatively or not correlated with Environment indicators 3. Scores for these 13 goals were averaged to create a Socioeconomics Index for each country (Y-axis, Figure 3.6)	Socio-economics & Governance	1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY
		6 CLEAN WATER AND SANITATION	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	
		10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	17 PARTNERSHIPS FOR THE GOALS	
1. Scores for 4 Environment Goals and the International Spillovers Score were averaged to generate an Environment Index for each country (X-axis, Figure 3.6)	Environment	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	14 LIFE BELOW WATER	15 LIFE ON LAND	International Spillovers Score

Figure 3.6 shows a detailed tracker by SD Goal for each country of the SCS-GoT region in dashboard format (Sachs et al. 2024). Notable achievements in poverty alleviation (SDG1) and in providing quality education (SDG 3) have been reached by Thailand, Vietnam, Singapore and China. Much work needs to be done in eradicating hunger (SDG 2), supporting good health (SDG 3), and providing access to clean water and sanitation (SDG 6), and affordable and clean energy (SDG 7). The growth of the economy to provide decent work and living wages, employing most of the adult population to create wealth at the individual and national scales, must be given high priority. This is most strategic in its role to address wealth inequalities (SDG 10) and in promoting sustainable urban environments (SDG 11) and building stronger institutions (SDG 16). The failing marks for protecting the marine (SDG 14) and terrestrial (SDG 15) environments are deeply concerning and are addressed in detail in Sections 4, 5, 6 and 7 of this regional analysis.

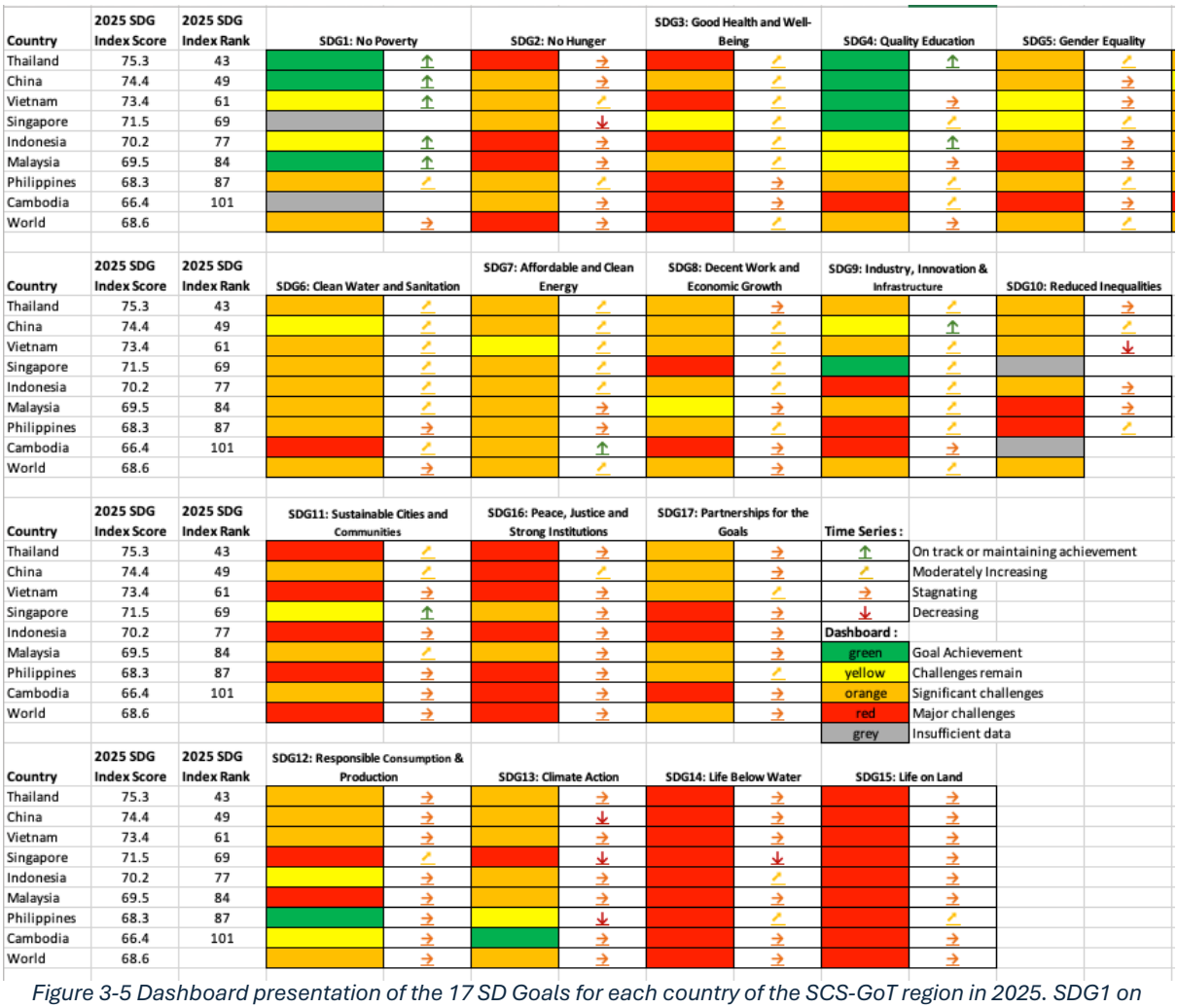


Figure 3-5 Dashboard presentation of the 17 SD Goals for each country of the SCS-GoT region in 2025. SDG1 on Poverty and SDG3 on Quality Education stand out as having elements that have been achieved. The other goals such as SDG 2 on Hunger and Good Health (SDG3) require more work, as do access to clean water and sanitation (SDG 6) and to affordable and clean energy (SDG 7).

The analysis of socioeconomic conditions in the SCS-GoT region indicates that the social thresholds for a decent quality of life remain to be realized for a significant share of the regional population. If one accepts that social capital underpinning human institutions remains the creative force behind good governance, including its economic and environmental dimensions, then ensuring the delivery of social goods and services should remain preeminent in development agendas at national, regional and global scales. If social, economic and environmental wellbeing are fundamentally intertwined, and are intrinsic to achieving human and planetary sustainability, then governance will have to innovate and design transformative actions to uplift social conditions. The current slow progress in achieving sustainable development goals for social wellbeing places people in the region at risk. Actions to directly mitigate subpar social conditions will have to be accelerated, given how these can undermine transboundary environmental governance and economic growth.

3.6. Recommended actions

This subsection is not intended to mitigate socioeconomic issues which clearly are beyond the purview of an environmental assessment, whether territorial at country-scale, or transboundary at large marine ecosystem scale. Rather, it highlights transformational actions that help redress essential social conditions, so that human resources, including vulnerable populations, can play their much-needed roles in addressing cross-border environmental issues.

- Gender equality recognizes that 50% of humanity, the women, are key in their still unrealized roles as co-leaders in environmental governance, economic diversification, and in social upliftment of the marginalized, in the SCS-GoT region. This regional analysis shows an optimistic scope for the SCS-GoT countries to close the gender gap by 2030. Education, more than health and income, is a consequential lever in enhancing both human development and gender parity, especially for women, who help make better informed decisions for their families and communities in all aspects of life. These include:
    - Leadership roles in community-based management efforts such as for habitat restoration, marine protected areas, community outreach for climate change education, among others
    - Leadership roles in branding sustainably caught fish and prepared fishery products for value added pricing
    - Leadership roles in plastic waste initiatives
    - Leadership roles in upscaling climate-friendly consumption practices such as power sources for cooking and lighting
    - Leadership roles in promoting climate-friendly food sourcing and consumption practices
    - Leadership roles in environmental planning, policy and governance.

- Poverty alleviation is perhaps the one goalpost that measures how society collectively values human wellbeing as a right. This regional analysis indicates that reducing poverty to the aspirational number of zero by 2030 requires a concerted and targeted effort between governance and civil society. The poor make up a significant portion of those at high flood risk. Transformational actions include:
    - Implementing cash transfer programs that enable marginalized households to educate their children through to their productive years AND participation in environmental governance activities. Examples of these in Indonesia and the Philippines have proven to be successful and require investment for upscaling.
    - Designing vocational programs that train and employ the youth in the service subsector of environmental programs, such as digitizing the monitoring of fishing effort; using social media platforms for citizen science, including community-based early warning for red tide, tropical cyclone and flooding events, among many others; and as agents of community outreach education programs on climate change, biodiversity loss and pollution.

4. Has the quality of coastal and marine waters changed?

4.1. TDA 1.0 versus TDA 2.0

The 2000 UNEP/GEF Transboundary Diagnostic Analysis for the South China Sea ranked the main sources and types of pollution (Figure 4.1). At the time, land-based domestic, agricultural, and industrial wastes, together with sediments, solid waste, hydrocarbons, ship-based discharges, and atmospheric inputs, were all judged to make moderate to high contributions to the degradation of rivers, coasts, and nearshore seas.

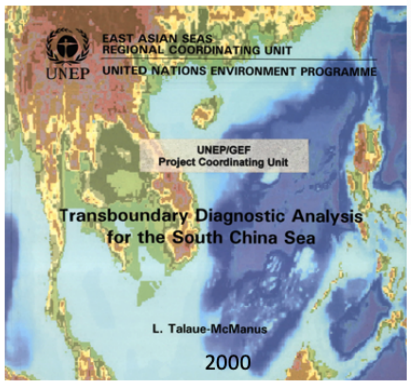


Table 3.48 Ranked sources of pollution among participating countries in the South China Sea[1]

Source	Rank & Data base	Contribution to pollution of national aquatic environments (L = Low, M = Moderate, H = High)						
		Ca	Ch	Indo	Mal	Phil	Tha	Viet
• Domestic waste	1-Fair	H	H	H	M	H	H	H
• Agricultural waste	2-Poor	M	H	H	M	H	H	H
• Industrial waste	2-Poor	M	H	H	H	H	H	H
• Sediments	3-Poor	M	H	H	M	H	H	H
• Solid waste	4-Fair	H	H	H	M	H	H	H
• Hydrocarbons	5-Poor	L	M	H	M	M	M	M
• Ship-based sources	6-Poor	M	M	M	M	M	M	M
• Atmospheric	7-Poor	M	M	M	M	M	M	M

[1]Ranking of pollution sources was done during the Second Meeting of National Coordinators (June 1998).

Table 3.65 Transboundary issues associated with pollution in TDA participating countries

Transboundary Issue – Quality of Information	Ca	Ch	In	Ma	Ph	Th	Vi
1. Pollution of transboundary rivers							
• Mekong River – Poor to Fair	✓	✓				✓	✓
• Red River – Fair (Viet Nam)		✓					✓
• Sai Gon-Dong Nai–Fair (Viet Nam)	✓						✓
2. Transport of polluted coastal waters along the Sunda Shelf–Poor	✓	✓		✓		✓	✓
3. Haze from forest fires – Poor			✓	✓	✓		
4. Acid precipitation – Poor		✓				✓	✓
5. Transport of waste for trade and recyling – Poor	No data	✓	✓	✓	✓	✓	No data
6. Coastal tourism – Fair	✓ 4	✓	✓	✓	✓	✓	✓

Figure 4-1 Transboundary issues associated with pollution in TDA 1.0 (2000).

In parallel, clearly transboundary issues—pollution transported by major rivers, contaminated coastal currents (for example, across the Sunda Shelf), regional haze and acid deposition, waste trade, and coastal tourism were singled out as problems that would require some form of joint or coordinated response.

4.2. More than two decades later, marine plastic and land-based nutrients are considered the two main transboundary contaminants of concern.

Nutrients and Eutrophication. Modeled results for 2015 suggest that rivers in the COBSEA region carried about 12 million tons of excess nitrogen and 1 million tons of excess phosphorus to the shelf, roughly double the load estimated for 1985 (McManus et al. 2022). Agriculture is the primary driver, responsible for an estimated 52% of nitrogen and 40% of phosphorus exports, primarily linked to intensive use of synthetic nitrogen fertilizers and leaching via agriculture-influenced groundwater. Domestic waste contributes a further 23% of nitrogen and 34% of phosphorus, while aquaculture adds around 8% and 9%, respectively, particularly in heavily farmed coastal areas.

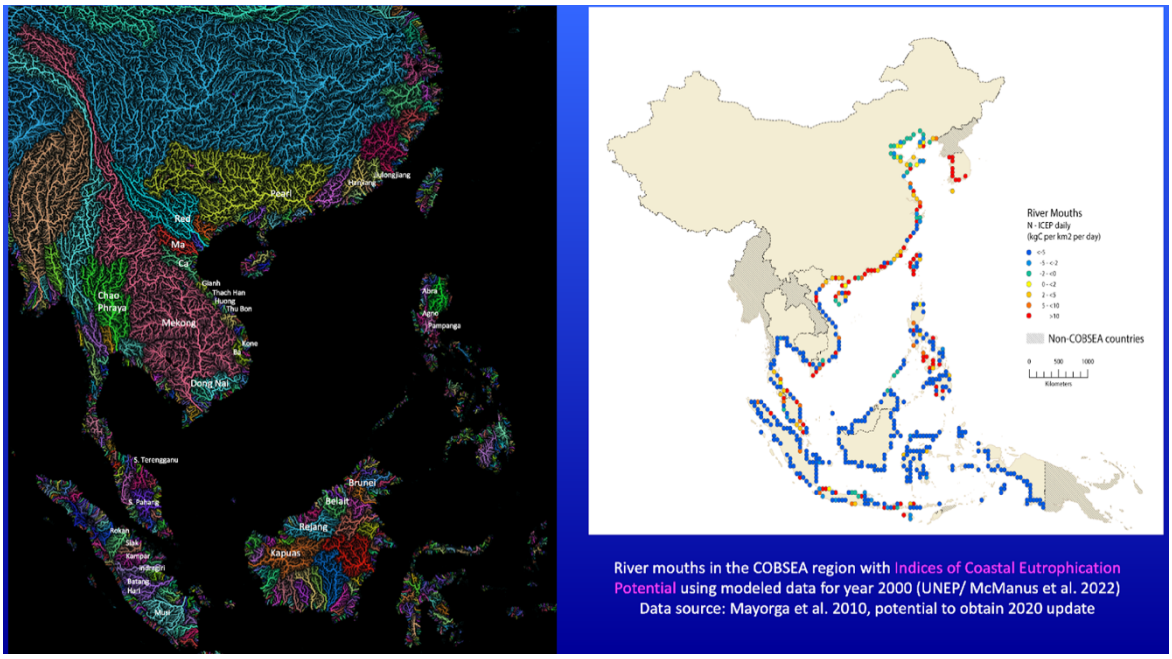


Figure 4-2 Coastal eutrophication in river mouths in the COBSEA region based on modeled data (McManus et al. 2022).

By 2000, eutrophication signals were already widespread: 100 national basins (about 19% of all basins, draining 45% of the total watershed area) were found to discharge to eutrophic coastal waters (Figure 4.2). The burden appears especially pronounced in the Republic of Korea (97% of basins affected), China (74%), and Singapore (67%). Excess nutrient inputs in these and other coastal zones fuel eutrophication, promote recurrent (and often toxin-bearing) algal blooms, and drive the formation of hypoxic "dead zones" as oxygen is stripped from bottom waters during decomposition.

Plastic Pollution. Recent global assessments suggest that ocean plastic pollution is heavily concentrated in a relatively small group of countries, with China (2.68 Mt), the Philippines (1.70 Mt), India (0.97 Mt), Indonesia (0.60 Mt), and Nigeria (0.50 Mt) accounting for most of the cumulative plastic leakage to the sea (Figure 4.3).

Three of these top emitters - China, the Philippines, and Indonesia - are South China Sea–Gulf of Thailand (SCS-GoT) TDA countries, and other TDA states (Vietnam, Thailand, Malaysia, Cambodia) also emerge as notable sources in regional maps of plastic waste entering the ocean (Figure 4.4). Taken together, the SCS-GoT countries appear to form a global hotspot of plastic leakage, even if methodological differences between assessments warrant some caution in interpreting the exact rankings.

Figure 4-3 Generation of ocean plastic waste by country, 2010 –2019 (https://www.visualcapitalist.com/where-the-worlds

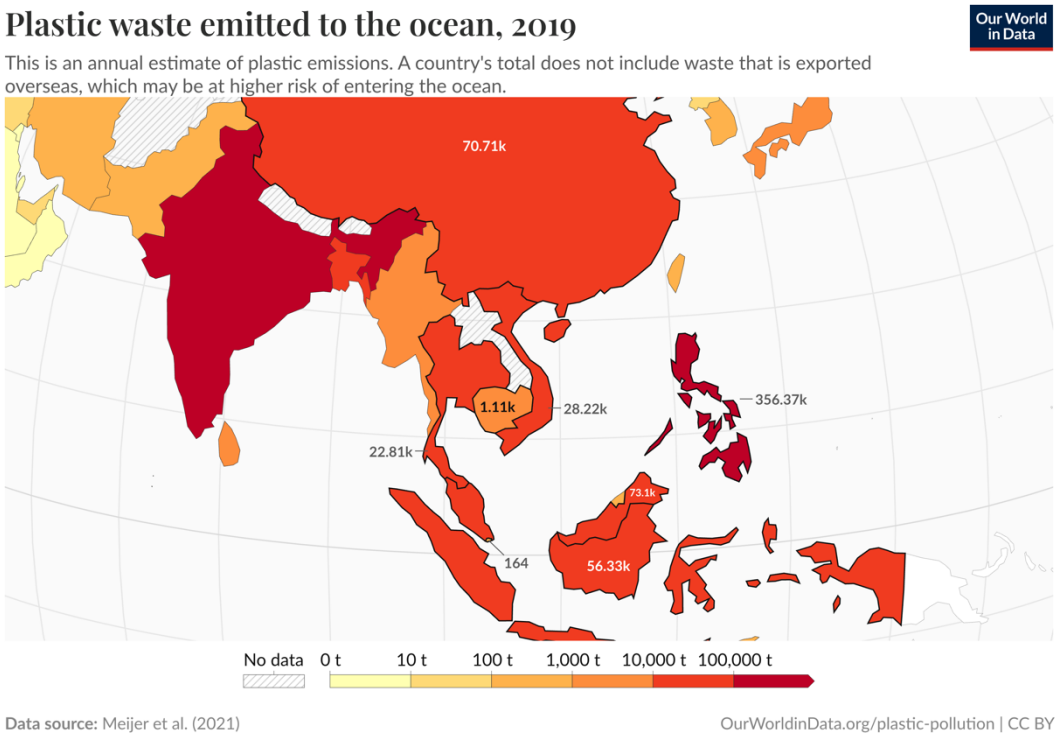


Figure 4-4 Top plastic emitters in the world are in the SCS-GoT region.

For policymakers, this pattern is likely to be both a warning and an opportunity: targeted action in this subregion could yield outsized benefits for the world's oceans. Priority directions include strengthening solid-waste and wastewater management in fast-growing coastal cities and towns; cutting single-use plastics and improving collection and recycling along major river basins that discharge to the SCS-GoT; and pursuing coordinated, region-wide approaches—shared reduction targets, compatible monitoring systems, and extended producer responsibility schemes—that address plastic leakage at its source rather than relying primarily on downstream cleanup efforts.

4.3. What has changed?

The TDA 2.0 asks whether the TDA 1.0 (Year 2000) assessment still holds in the 2020s, but also widens the lens. It revisits the earlier ranking of concerns and their relative importance while explicitly adding marine plastics as a major transboundary pollutant, now placed alongside sewage, nutrient enrichment, and freshwater-related stresses, all interpreted against the backdrop of the "triple planetary crisis" of climate change, pollution, and biodiversity loss.

Land-based and river-borne pollution still dominate the picture. At the same time, the current TDA also suggests that policymakers can no longer simply apply the old priority list. There is a clear need to recalibrate interventions to keep pace with rapidly escalating plastic leakage and intensifying climate-driven pressures, especially when planning for 2030 and 2050 horizons.

4.4. Beyond the Pollution Indicators

The Environmental Performance Index (2024) ranks 180 countries using 58 indicators across 11 issue categories under three policy objectives (Figure 4.5). Each indicator is normalized to a 0–100 proximity-to-target score and weighted to the category and overall results.

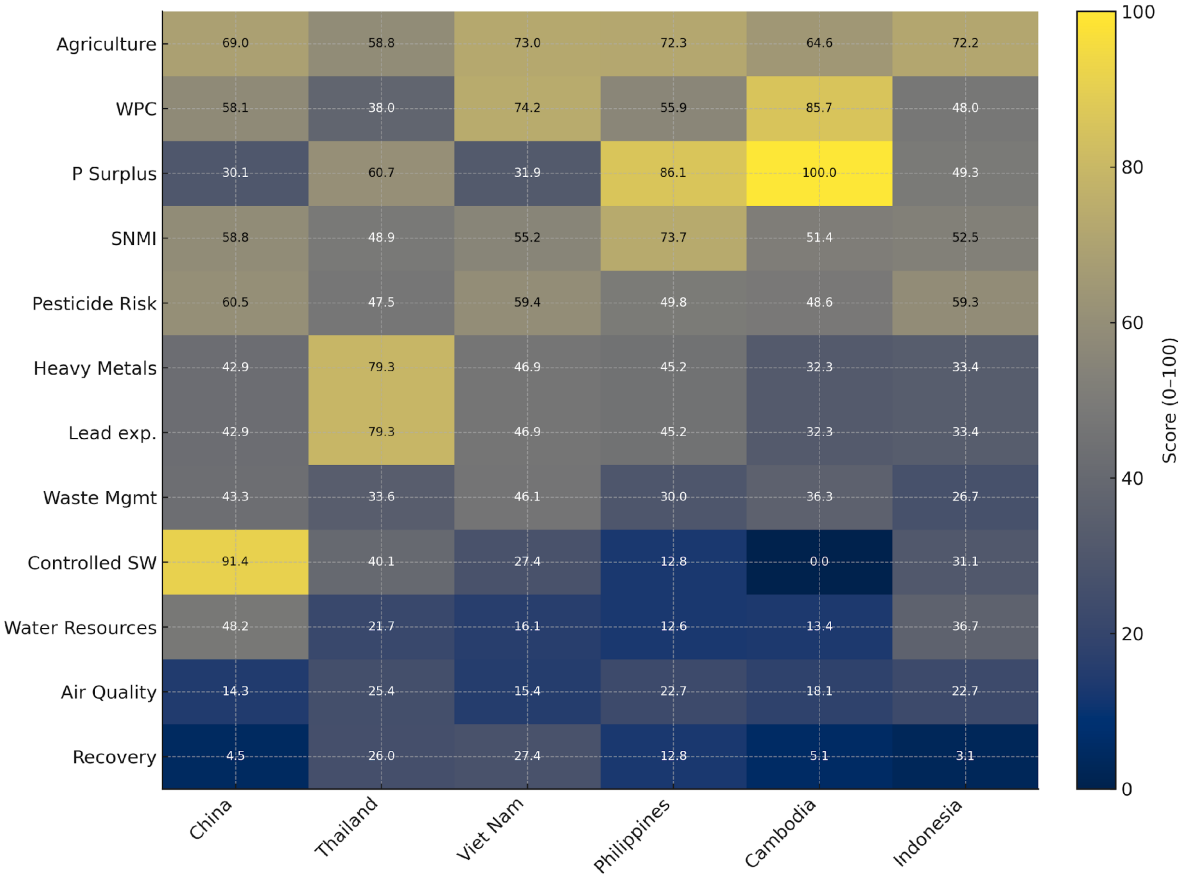


Figure 4-5 Environmental Performance Indicator Scores among SCS-GoT countries. 2024 EPI scores on a 0-100 scale (higher = better performance). These are normalized index values, not percentages. Each category/ indicator aggregates multiple measures on a proximity-to-target basis. Rough guide: 80-100 leading, 50 middling, 0-30 large gap to targets.

The heat map shows wide disparities among the six SCS–GoT countries in 2024 EPI pollution indicators (0–100), where scores near 80–100 suggest strong performance and scores below 40 indicate major gaps. China performs relatively well on controlled solid waste, while Thailand leads on heavy metals and lead exposure—likely reflecting stronger industrial controls and cleaner fuel standards. A few countries score better on phosphorus surplus and Sustainable Nitrogen Management Index (SNMI), but most cluster mid-range, implying continuing risks of eutrophication and coastal hypoxia. All six score poorly on water resources, air quality, and recovery, pointing to shared structural weaknesses that amplify land-based pollution loads to the sea.

For the TDA-SAP 2.0, the EPI scores among SCS-GoT countries thus offer both opportunities and cautions: there are concrete, in-region examples that can serve as practical models for specific interventions, but the broader policy signal is the need for coordinated and sustained investment in land-based pollution control, solid waste and wastewater infrastructure, and air-quality management if the region is to narrow the gap with global best practice.

4.5. Severe Typhoons as Manifestations of Climate Change in the SCS-GoT

For countries bordering the South China Sea and the Gulf of Thailand, typhoons now pose intertwined economic and environmental risks. Major storms can generate losses in the tens of billions of dollars, often with limited insurance coverage, but they also appear to trigger episodic, high-volume discharges of pollutants that deepen damage well beyond the immediate wind and flood footprints (Figure 4.6). Intense rainfall and storm surges can

mobilize sewage, solid waste (including plastics), agricultural runoff, mine tailings, and industrial effluents, rapidly flushing them into rivers, estuaries, and nearshore waters. The result is often a short, violent spike in contamination (e.g., fish kills, murky plumes, and stress or damage to coral reefs, mangroves, and seagrass beds) that undermines fisheries, tourism, and coastal protection at precisely the moment communities are trying to recover.

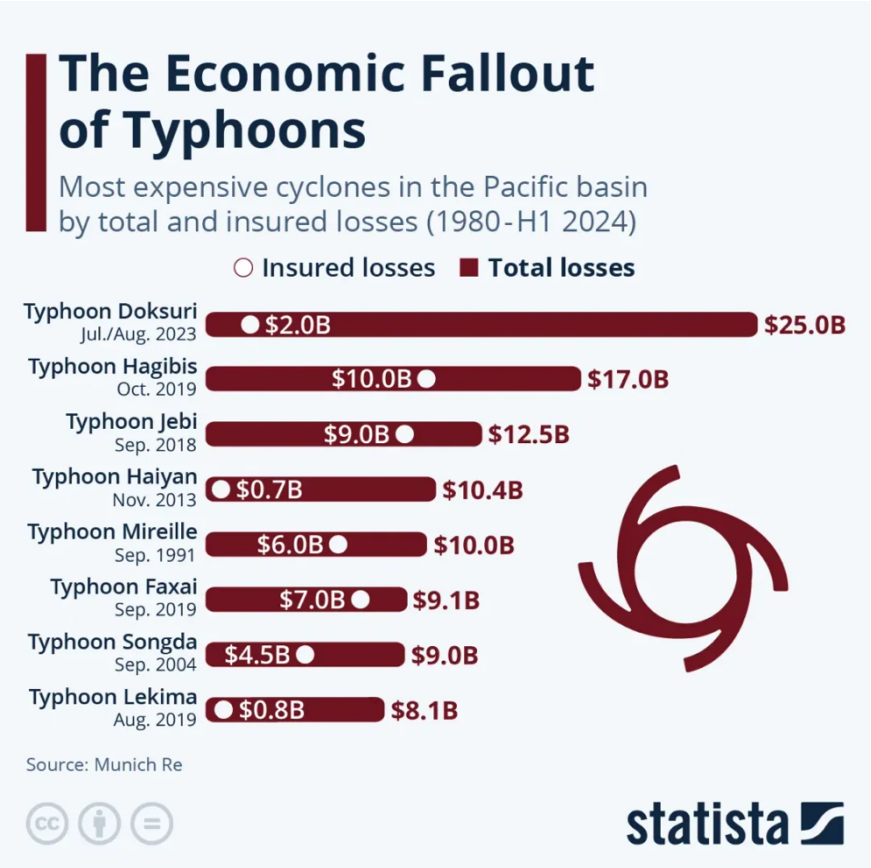


Figure 4-6 Typhoons cause expensive losses. https://www.voronoiapp.com/other/The-Economic-Fallout-of-Typhoons-2379

For SCS–GoT countries, this suggests that typhoon risk management cannot be treated separately from pollution control and climate resilience. It calls for stronger solid-waste and wastewater systems, safer siting and design of industrial facilities, and land-use planning that lowers the chances that each major storm becomes both an economic shock and a toxic pulse to the marine environment.

4.6. What interventions among countries vis-à-vis pollution have demonstrated or resulted in significant positive change?

Fertilizer Action Plan in China. In 2015, China launched its “Zero-Growth Action Plan for Fertilizer”, and its government policies have played an essential role in this turnaround. Because subsidies made fertilizers less costly in China, farmers overused them. Cutting subsidies and encouraging agricultural technology, precision technologies, farmer education, and larger farms (which use less fertilizer per hectare) have made China's farming sector more efficient and lessened fertilizer use (Figure 4.7).

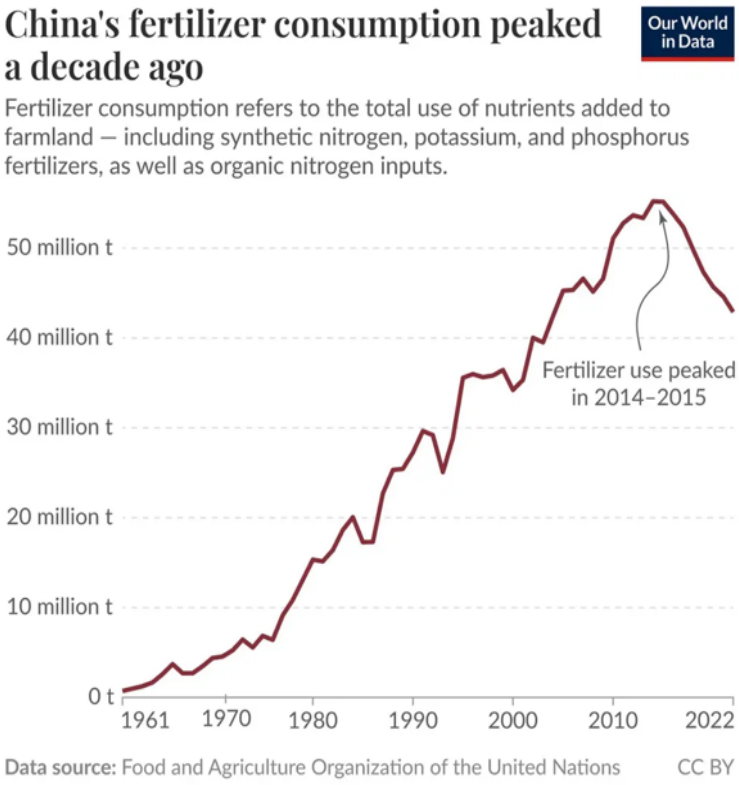


Figure 4-7 Fertilizer consumption in China from 1961 to 2022 reached a peak in 2024-2015.

Plastic Waste Reduction. The Global Plastic Toolbox explores how plastic outcomes may change under different policy scenarios, starting from current levels of mismanaged waste, including plastic waste that ends up in the ocean (Figure 4.8). On the overview tab, you can mix and match broad policy options to see how different combinations could reduce overall waste in comparison to business as usual.

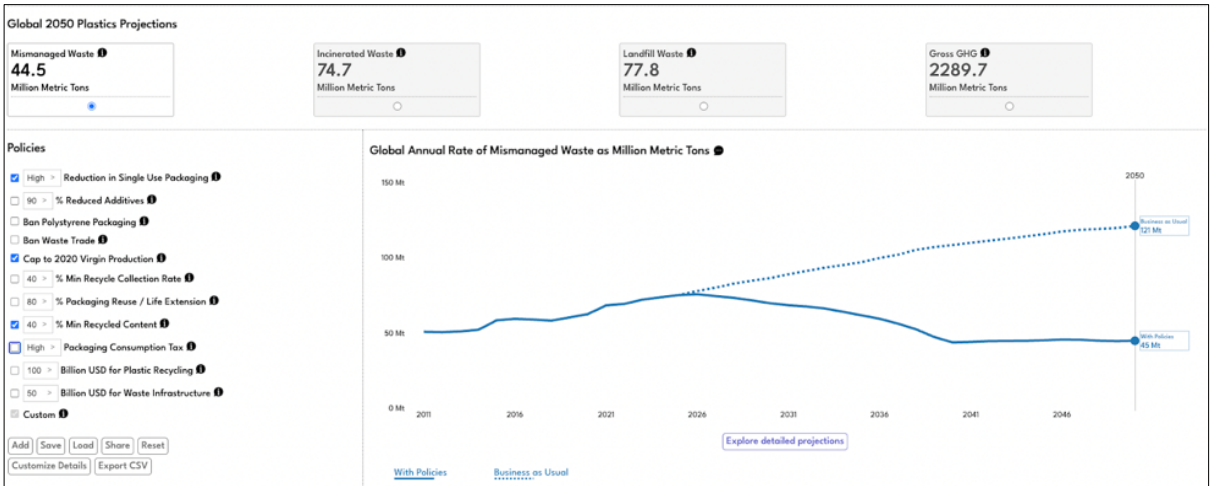


Figure 4-8 The Global Plastic Toolbox provides a menu of policy interventions that can significantly reduce plastic waste (https://global-plastics-tool.org/#overview) if implemented effectively.

Plastic Governance. The Institutional and legal policy framework on pollution from marine plastics in ASEAN+3 diagram outlines a governance framework that links global marine pollution treaties with ASEAN, and East Asian (ASEAN+3) regional seas bodies (Figure 4.9, Lyons and Neo, 2019). By clarifying which institutions lead on waste, chemicals, shipping, and fisheries, it helps countries harmonize plastic-related laws, coordinate regional action plans on marine litter, and share data and capacity—supporting a more coherent ASEAN+3 response to plastic pollution.

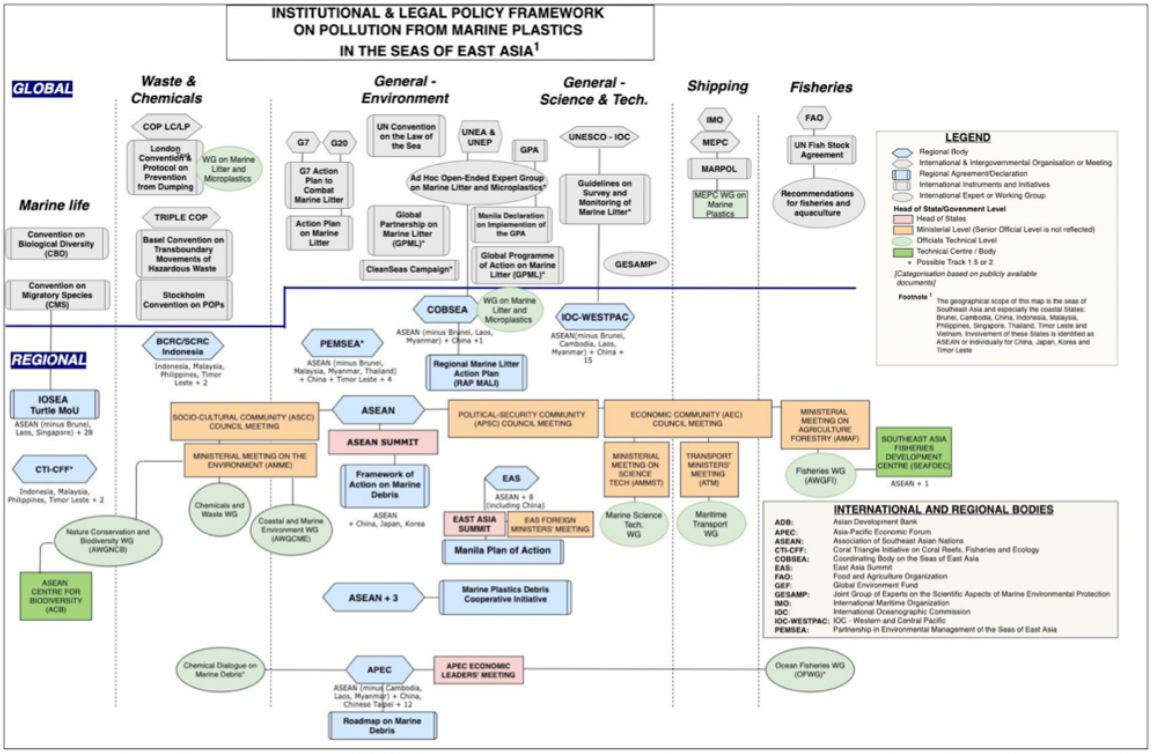


Figure 4-9 Plastic governance for the Seas of East Asia (Lyons and Neo, 2019).

5. Are marine habitats in the South China Sea and Gulf of Thailand at risk?

5.1. Trends in habitat changes

Habitat losses. The annual rates of mangrove loss in the seven countries (Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand and Vietnam) between 1990 and 2000 were greater than the world average, 1.61% compared with 1.04% (UNEP, 2004). UNEP (2008) estimated the decadal rate of mangrove loss in the SCS and GoT in 2007 at 16%. The mangrove trend of change has become positive during the period 2000-2020, as deforestation rates are lower than previously recorded. Mangrove deforestation remains substantial across Southeast Asia (SEA), with more than 100,000 ha of mangrove forest lost (0.18% per year) between 2000 and 2012 (Richards and Friess, 2016). The rate of annual mangrove area change between 2000 and 2020 (FAO, 2020) was +2.32% in East Asia and -0.17% in South & Southeast Asia (the highest loss compared with other regions in the world). It has been estimated that around 30% of coastal wetlands are lost in Southeast Asia each decade resulting in an approximate annual loss in value of 3% per annum (UNEP, 2008). Wetland loss in recent years has not been recorded but reduction of the extent and quality of coastal and inland is considered a challenge (Conklin et al., 2014).

The SCS Project estimated the ongoing decadal rate of degradation in live coral cover from the SCS and GoT in 2007 as 16% (UNEP 2007). Long term monitoring data indicates a complex trend in the change of Southeast Asia coral reefs (Souter et al., 2020). While coral cover has increased slightly over the last 37 years, it has declined slightly over the last decade. Comparison of the average hard coral cover over 15 years (2005-09, 2010-14, 2015-19) indicates that, despite the uncertainty in individual yearly estimates, there is strong evidence (96% probability) that average coral cover has declined. On average (for 15 years), this decline equates to a loss of almost 11% of the hard coral, of which more than 90% occurred between 2005-09 and 2010-15. Figure 5.1 (redrawn from Souter et al., 2020) indicates the trend in changes in the eco-region of SCS. With that, coral cover has fluctuated with a high range over time in eco-region 3 (southern SCS and GoT), declining slightly in eco-region 6 (northern SCS). The trend of change of coral covers in the eastern SCS (a part of eco-region 1) appeared stable, with slight temporal variability.

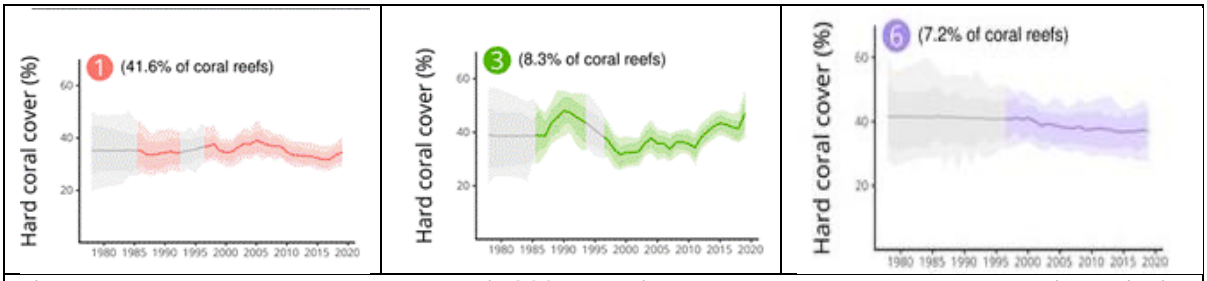


Figure 5-1 Trends of changes of coral covers in SCS eco-regions based on long term data collected in monitoring sites (% - portion compared with total Southeast Asia reef area).

In 2006, the estimated ongoing decadal rate of loss of seagrass habitat in the SCS and GoT in 2006 was approximately 30% (UNEP, 2006, 2008). Recently, temporal changes in seagrass bed area, analyzed for 68 sites in nine countries in SEA, demonstrated that more than 60% of seagrass beds declined at an average rate of 10.9% per year, whereas 20% of beds increased at an average rate of 8.1% per year, leading to an overall average decline of 4.7% per year. Regarding geographical variation in the patterns of temporal change, more seagrass beds are declining in Vietnam and southern mainland China, whereas most seagrass beds are stable

and/or increasing along the coast of Thailand (Sudo et al., 2021). Fortes (2018) indicated continuous seagrass decline in Southeast Asia. It means that seagrass loss has remained quite severe, and may even have increased in the region.

Habitat modifications. Generally, regional reviews mainly focus on the loss of mangroves, wetlands and seagrass areas, and on changes in coral cover. More detailed studies (Conklin et al., 2014; Brian-Brown et al., 2020, Morrison & Aalbersberg, 2022; Suthacheep et al., 2022; and Vo Si Tuan & Nguyen Van Long, 2022).) indicate strong evidence of habitat modification, such as:

- Changes of communities, including the decline of abundance of habitat- building species and species richness due to human impacts and coral bleaching
- Reduction in biomass & fishery resources by overfishing, destructive fishing, sedimentation & coral bleaching
- Fragmentation of mangroves caused by aquaculture and reclamation
- Loss or decline of endangered, threatened and migrating species due to illegal exploitation, bycatch fishing and habitat damages
- Reduction and loss of resilience to climate change under cumulative pressures of human impacts

Threats and impacts. Figure 5.2 below shows the loss and impact of anthropogenic activities on mangroves, indicating that aquaculture remains severe in the SCS and GoT. This impact also damaged many seagrass beds and wetland areas, as cage culture has been more developed in the coastal waters. Urban development, with more infrastructure for residential, tourism, and coastal development, has increased threats to all habitats due to landfills, reclamation, sedimentation, and eutrophication. Impacts of human activities on the sea, such as fisheries, tourism and island infrastructure, have increased, especially on coral reefs and seagrass beds, mainly resulting from overfishing, destructive fishing, physical damage and buries. As a consequence of environmental degradation, Crown of Thorn Starfish outbreaks occurred more frequently and killed a large number of reef corals in the SCS.

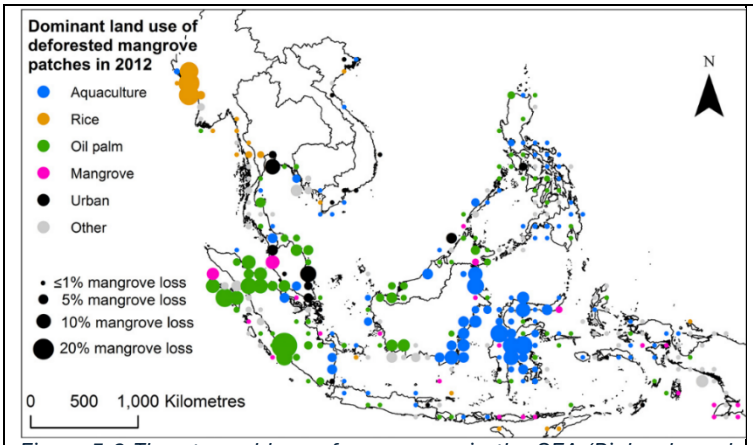


Figure 5-2 Threats and loss of mangroves in the SEA (Richards and Friess, 2016)

As FAO (2020), global drivers of mangrove loss, 2000–2020 indicated severe impact of aquaculture and less impacts from natural disasters.

Anthropogenic threats to mangroves in the SCS (UNEP, 2008): 1. Reclamation and infrastructure development (all countries); 2. Pollution from shrimp farming (China, Indonesia, Thailand); 3. Industrial conversion (primarily in China, less in the Philippines, Indonesia and Viet Nam;, negligible in Cambodia, and Thailand); 4. Charcoal production (Indonesia, Philippines and Cambodia) and 5. Conversion to shrimp culture poses a long-term threat in Viet Nam.

In addition, challenges in recent decades, due to extreme weather, have increased and are now occurring more frequently in the SCS. Typhoons have caused physical damage to coral reefs and mangroves, which is more severe in the North and Central SCS; flooding has

increased freshwater and sedimentation inundation resulting in the degradation of nearshore coral reefs, and seagrass beds in Central Vietnam. Catastrophic fires, such as those in 2015, severely damaged peat swamp systems in Sumatra and Kalimantan (Indonesia).

A series of publications indicate clear evidence on the impacts of increased sea surface temperature on coral reefs in the SCS and GoT under four mass global bleaching events (1998, 2010, 2014-2017), 2024), and also at regional (2019) and local levels (see Figure 5.3 for the 2010 event).

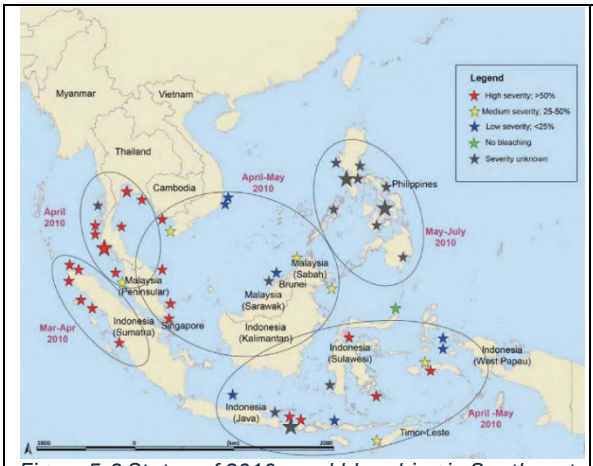


Figure 5-3 Status of 2010 coral bleaching in Southeast Asia (Tun et al., 2013)

During the 3rd Global Mass Bleaching Event (2014-2017), the impact on coral reefs in SEA was widespread with the greatest bleaching severity reported in 2016. The bleaching levels varied significantly among eco-regions (Kimura et al., 2018):

- Low in South Vietnam;
- Medium in Southwestern Vietnam,
- Low to medium in Cambodia;
- Low to high in Thailand;
- Medium to high in Singapore;
- Medium in Indonesian SCS.

5.2. Recommended regional actions

- Support the effective management of biodiversity hotspots and sensitive areas in the SCS-GoT countries, through guiding management measures and restoration technologies which are appropriate to habitat status, impacts, and resilience at the local levels
- Development and operation of marine protected areas (MPAs) and Other Effective Area-Based Conservation Areas (OECM) networks, and provide support to improve their management effectiveness and ensure ecological connectivity
- Establishment of a regional network for conservation of migrating species, exchanging innovation techniques and management practices across their nesting and feeding areas and preventing bycatch fishing along their migrating routes
- Provision of support to implement measures to ensure resilience to climate change, reducing long term cumulative impacts from anthropogenic threats and planning for unpredictable events
- Improvement of monitoring and evaluation, reporting and policy briefing to enable adaptive management at all levels
- Multiple cooperation for transboundary management of habitat conservation, fisheries refugia, blue carbon, transboundary pollution and protection of migratory species

6. Are the fisheries of the South China Sea and the Gulf of Thailand at risk?

6.1. Role of Fisheries and Aquaculture

The South China Sea (SCS) and the Gulf of Thailand (GoT) are among the world's most productive marine ecosystems, playing an essential role in ensuring food security, nutrition, and livelihoods for approximately two billion individuals residing in the riparian nations. In the 2000 TDA, Talaue-McManus (2000) noted that marine capture fisheries production from the SCS countries accounted for approximately 8.2% of the global total during the 2000s, while aquaculture accounted for 54.0% of the worldwide figure. It is crucial to recognize that by 2022, the total output from nine riparian nations was approximately 26.87 million tons of marine capture products and 96.11 million tons of aquaculture products, accounting for about 21.2% and 73.9% of global production, respectively. Data on per capita fish consumption clearly demonstrate that five out of nine nations—Malaysia, Brunei, China, Indonesia, and Cambodia—exceed 40 kg per person annually, with Malaysia recording the highest at 52.17 kg. Figure 6.1 notably surpasses the global average, underscoring that fish is not merely an occasional dietary item but a fundamental, regularly consumed source of animal protein.

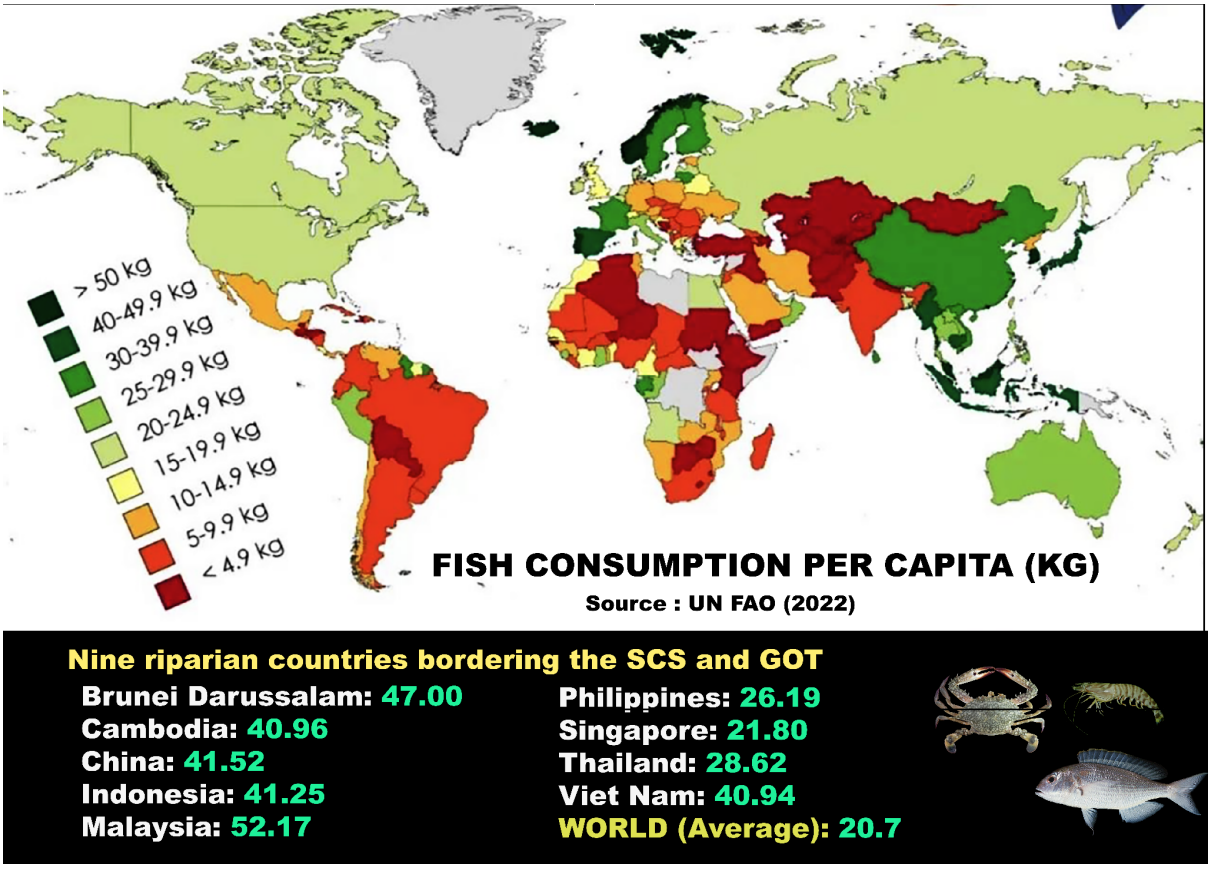


Figure 6-1Fish consumption per capita (kg) in the SCS-GoT countries in 2022.

6.2. The Critical Situation: Two Ecosystems Under Severe Stress

Nonetheless, decades of intensive fishing have led to severe overexploitation in both Large Marine Ecosystems (LMEs).

- **The Gulf of Thailand** has undergone a classic "boom and bust" cycle. Biomass of demersal fish has decreased by more than **86%** since the 1960s (Figure 6.2). The average trophic index declined from 3.46 in 1965 to 2.88 in 1995. The ecosystem was significantly degraded, predominantly composed of lower-value species and jellyfish, with most commercial stocks either overexploited or collapsed. By 2019, over 80% of the individual fish stocks in the Gulf of Thailand were classified as collapsed, indicating their catches are less than 10% of their historical peaks. This situation constitutes not only an economic challenge but also a critical biodiversity crisis.

- **The South China Sea** is larger and more diverse; however, it is also extensively overexploited. The total fish biomass is estimated to be only **5-30%** of the pre-exploitation levels. The average trophic index declined from 3.72 in 1965 to 3.50 in 1995 (Figure 6.2). The ongoing increase in total catch masks a severely depleted ecosystem, sustained solely by intense fishing and the sequential depletion of species throughout the food web. In other words, total primary production required (PPR) in the South China Sea continues to increase, suggesting the system is being intensively and possibly overexploited. By 2019, approximately 60% of the 321 individual stocks in the SCS were classified as collapsed. Although this situation is devastating, it represents a lower percentage compared to the Gulf of Thailand.

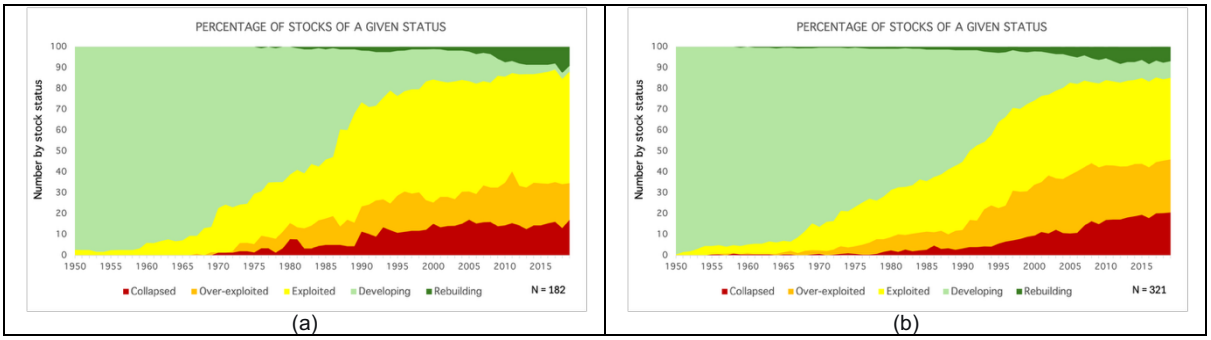


Figure 6-2 Stock status in the Gulf of Thailand (a) and in the South China Sea (b).

6.3. Key Drivers of the Crisis and Risks

- **Massive overcapacity and destructive gear are significant concerns.** Industrial fishing, especially bottom trawling—which constitutes nearly half of all catches—serves as a primary driver. These techniques exhibit exceptionally high bycatch rates of 80-90% in specific regions, such as the Gulf of Thailand, southeast of Vietnam, and the Gulf of Tonkin, causing extensive damage to vital seabed habitats and resulting in a dramatic decline in Catch Per Unit Effort (CPUE) and overall fish biomass, as shown in Figure 6.3.

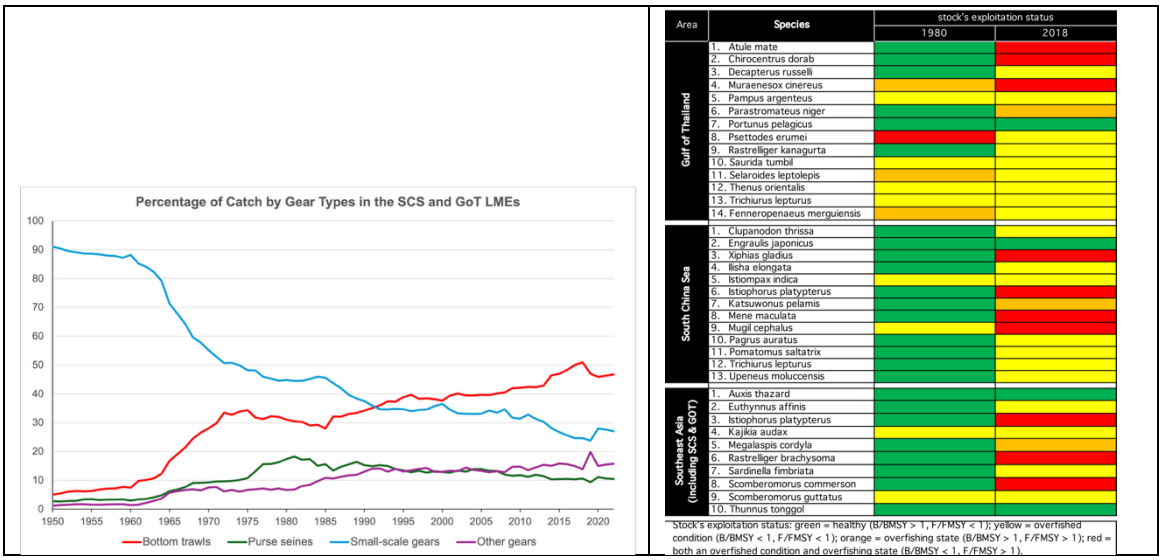


Figure 6-3 Percentage of catch by gear types in the SCS and GoT LMEs (Left). Right panel indicates the stock exploitation status of listed species in the Gulf of Thailand, South China Sea, and regionally in Southeast Asia.

- **Harmful subsidies:** Government subsidies that increase fishing capacity constitute a significant economic distortion. In the five SCS countries examined, these detrimental subsidies predominate, and their share of the landed catch value is alarmingly high, effectively subsidizing the overexploitation of already depleted resources, as shown in Figure 6.4.

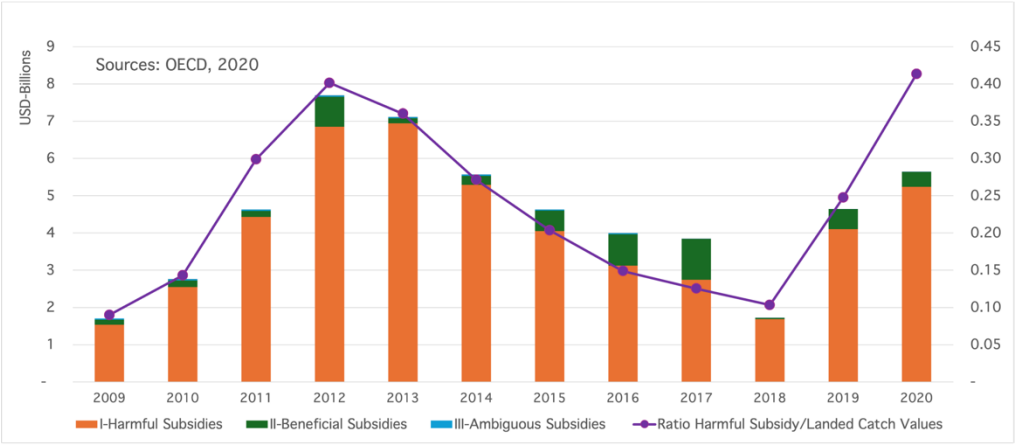


Figure 6-4 Fisheries subsidies from five countries bordering the South China Sea from 2009 to 2020.

- **Aquaculture Growth:** While aquaculture now produces 76.6% of the region's seafood and helps meet demand, its rapid, intensive growth—particularly in delta regions like the Mekong and Pearl River Deltas—creates new environmental challenges. The aquaculture industry may exert adverse ecological effects, including eutrophication resulting from surplus feed and waste, which has contributed to algal blooms. The removal of mangroves for shrimp pond development has reduced coastal resilience. Moreover, disease outbreaks, such as those in shrimp farming, have prompted increased chemical usage, thereby exacerbating water contamination.
- **Climate Change:** Rising sea temperatures, ocean acidification, and more frequent extreme weather events (e.g., typhoons) are already affecting fish distribution and reproductive cycles (Table 6.1), and damaging aquaculture infrastructure, posing a significant long-term threat to productivity and resilience.

Table 6-1 Observed impact of El Niño phenomenon in the Gulf of Thailand in 1997-1998 and in 2015-2016.

Factors/Species	Observed Impact of El Niño phenomenon in Gulf of Thailand	
	1997-1998	2015-2016
SST Anomaly	+1.5–2.5°C	+1.0–1.8°C
Pelagic Catch Drop	25–50%	15–30%
Short mackerel	↓ 30–40% decline in catches due to migration to deeper waters	↓ 20–30% decline in catches; shifted eastward
Anchovies	↓ 50% drop in some areas due to plankton decline	↓ 30–40% drop (worse in central Gulf)
Sardines	↓ 20–30% reduction in landings	↓ 15–25% reduction, slower recovery
Recovery Time	2–3 years	1–2 years

Climate change affects seawater quality (Srisunont et al., 2012), thereby significantly influencing phytoplankton populations and contributing to red tide bloom phenomena. These algal blooms pose substantial threats to fish populations and the aquaculture industry. Fish fry and cultured fish were affected by Gymnodinium sp. in waters off Hong Kong and Guangdong in 1998, resulting in economic losses of 100 million RMB (Huang et al., 2018). Furthermore, Vietnam is projected to lose between 10 and 15 percent of its Mekong Delta aquaculture area by the year 2050 due to rising sea levels. More severe typhoons, such as Haiyan in 2013 and Rai in 2021, have caused destruction to cages and ponds.

- **Inadequate and Fragmented Governance:** Management is overwhelmingly national, while the fish stocks and environmental impacts are transboundary. There is **no effective regional management body** with the authority to set binding catch limits or regulations for the SCS. A critical lack of shared, scientific data further hampers cooperative management.

6.4. Priority Actions for Sustainable Management of Two Ecosystems

Table 6.2 Priority Actions for the Gulf of Thailand "Recovery Challenge" and the South China Sea "Prevention Challenge".

Aspects	Gulf of Thailand The "Recovery" Challenge	South China Sea The "Prevention" Challenge
Focus:	● Drastic reduction of fishing capacity, particularly of bottom-trawling vessels	● Avoid the collapse through immediate regional cooperation
Immediate Actions:	● Effective management requires unprecedented bilateral cooperation, robust enforcement, and a concerted effort to reduce fishing capacity and break the economic cycle that depends on the systematic harvest of the entire ecosystem. This approach may be applied to specific areas, such as the Gulf of Tonkin in the SCS.	● Establish a Regional Fisheries Management Organization (RFMO): This is the most critical step. A cooperative, science-based RFMO is essential to set shared Total Allowable Catches (TACs), manage transboundary stocks, and protect critical offshore and spawning areas.
Cross-Cutting Recommendations:	● Strengthening regional cooperation to eliminate Illegal, Unreported, and Unregulated (IUU) fishing. ● Enhancing coordinated regional Monitoring, Control, and Surveillance (MCS) systems, including vessel monitoring and port-state measures. ● Strengthening regional and transboundary cooperation on joint stock assessments for key shared species, establishment of a shared IUU vessel information system, joint habitat-protection initiatives, such as linked MPAs, mangrove corridors, and pollution-containment zones ● Adopt Ecosystem-Based Fisheries Management (EBFM): Move beyond single-species management to manage the entire marine ecosystem, considering climate impacts and food-web interactions. ● Invest in shared science: Prioritize collaborative data collection and joint stock assessments to build a foundation of trust and evidence-based decision-making. ● Phase out harmful subsidies: Redirect public funds from capacity-enhancing subsidies to support science, enforcement, fleet buy-backs, and the development of sustainable livelihoods for coastal communities. ● Enhancing capacity on fisheries management, R&D, and data & information sharing ● Promoting good practices for sustainable aquaculture	

Conclusion. The marine living resources of the South China Sea and the Gulf of Thailand are a shared asset facing a common crisis. Without immediate, concerted, and regionally coordinated action to reduce fishing pressure, eliminate harmful subsidies, and strengthen governance, the economic stability and food security of all bordering nations will be severely compromised. The time for decisive policy intervention is now.

7. How are countries of the SCS-GoT collaborating to protect a shared sea at risk?

Figure 7-1 Configuring the environmental governance of the South China Sea and Gulf of Thailand Large Marine Ecosystems.

7.1. The importance of a transboundary approach to manage the SCS and GoT

The SCS and GoT constitute two of the world's most productive and vital LMEs, supporting a unique array of marine biodiversity and providing critical ecosystem services for a substantial portion of the global population (Whisnant & Vandeweerd 2019). Their coastal and marine resources are indispensable for the livelihoods of nearly two billion people living in the surrounding areas (Ortuoste 2024). Beyond its ecological importance, the seas function as a major artery for international trade, with an estimated one-third of global maritime commerce transiting its waters annually (approximately $3.37 trillion to $5.3 trillion worth of goods)(Center for Strategic and International Studies 2016). This dual significance—as a biological and economic lifeline—underscores the profound stakes involved in its environmental health.

The physical nature of this shared resource dictates a transboundary approach to its management (Figure 7.1). Environmental degradation, whether it be pollution or habitat, is not contained by national boundaries, increased by climate change, a triple planetary crisis. The cumulative impact of activities from multiple riparian states, including Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand, Singapore, and Vietnam, necessitates a coordinated, multinational response. Recognising this, GEF has sought to act as a catalyst for cooperation among these countries since 1992, promoting a collaborative framework to address shared environmental pressures. Globally countries are party to relevant coastal and marine frameworks including UNCLOS, CBD, CITES, MARPOL, Paris Agreement, OPCR, and Asean Agreement (see Table 7.1) and BBNJ, CMS, UNEA 5 and the SDGs, to name a few. This is within a wider complex web of regional institutions with different geographical scope and mandates.

Table 7-1Global coastal and marine treaties ratified by SCS and GoT countries.

	UNCLOS	CBD	CITES	MARPOL	OPCR	London Convention	London Protocol	Paris Agreement	Asean Nature Agreement
Cambodia									
China									n/a
Indonesia									
Malaysia									
Philippines									
Singapore									
Thailand									
Vietnam									

SDG 14, Life Below Water, aims to conserve and sustainably use the oceans, seas, and marine resources, with the achievement of this within the SCS and GoT, highly critical to global progress on this goal. In the region, overall, progress towards SDG 14 is stagnating with all countries facing significant challenges and are "off track" for achieving by 2030. Most countries are struggling with marine pollution and sustainable fishing, with five of the top ten global plastic-polluting countries located in Southeast Asia. Positively, progress can be observed in an increased proportion of marine key biodiversity areas that are protected (Figure 7.2) (Sustainable Development Solutions Network 2025).

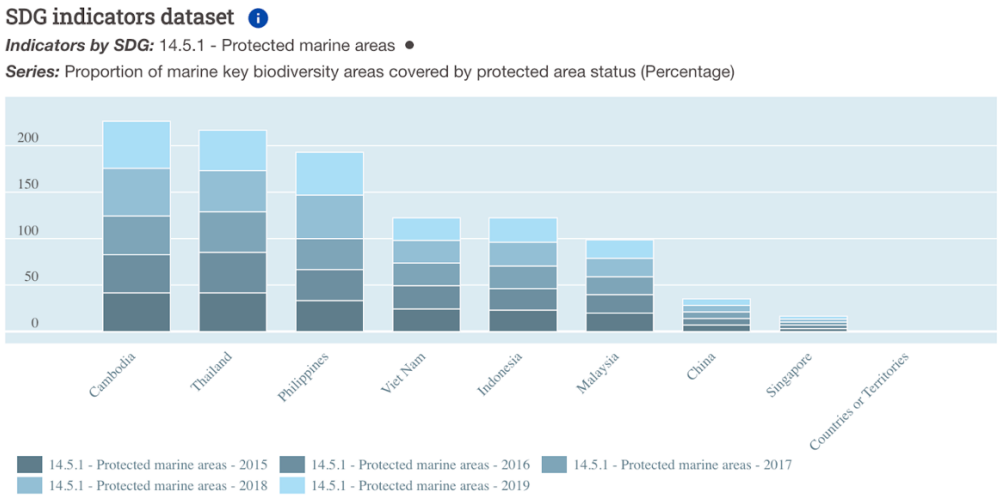


Figure 7-2 SDG: 14.5.1 Protected marine areas in SCS and GoT (2015-2019) Source: SDG Gateway - Asia Pacific - https://dataexplorer.unescap.org/

7.2. Existing regional platforms collaborating to protect the shared seas

Regional cooperation is a strategic driver for sustainable ocean use. Regional mechanisms apply efforts to implement key global agreements and bridge global commitment to local action. The most significant collaboration to protect the shared seas is centered around the SCS SAP. A major, multi-year/country initiative funded by GEF and implemented by UNEP. The project focuses on reducing habitat degradation and loss (mangroves, coral reefs, seagrass, wetlands), managing land-based pollution, and promoting sustainable use of marine resources (like fisheries). It involves national and regional working groups, National Action Plans, and development of best practices for coastal and marine ecosystem management. The project also supports local action through programs like SEA Grants, which fund community-based conservation projects across the region. TDA 2.0 and SAP 2.0 fall under this project. Starting in 1996, the project is expected to be completed by 2026.

Several regional intergovernmental mechanisms are providing a crucial "neutral ground" through soft laws for collaboration as summarised in Table 7.2.

Table 7-2 ***Regional intergovernmental mechanisms for environmental governance and cooperation in the SCS and GoT***

Mandate and contribution	Partners / Member Countries
Coordinating Body on the Seas of East Asia (COBSEA)	
Promotes the sustainable development and protection of the marine environment and is the decision-making body for the East Asian Seas Action Plan, focus is to strategically address marine pollution, ecosystems, and climate action. Provides a forum to collaborate on marine issues and scientific research allowing pragmatic dialogue on shared, transboundary environmental threats, and promoting environmental compliance through good will. COBSEA is making positive ground in establishing a Regional Marine Protected Area Network and addressing regional pollution.	UNEP Regional Seas Programme Partner of the SCS SAP Project Cambodia, China, Indonesia, DR Korea, Malaysia, Philippines, Singapore, Thailand and Vietnam,
Partnerships in Environmental Management for the Seas of East Asia (PEMSEA)	
A home-grown coordination body emerging as a bottom-up response to a perceived lack of regional policy/coordination capability is a regional coordinating mechanism for the sustainable development of coastal and marine areas in the East Asian Seas region.	UNDP All SCS and GoT countries, except China. Stakeholders including national and local governments, the private sector, and civil society.
Association of South East Asian Nations (ASEAN	
• ASEAN Nature Agreement • Working Group on Nature Conservation and Biodiversity (AWGNCB) for conservation and sustainable use of biological diversity functions and Centre for Biodiversity (ACB): facilitating cooperation to address biodiversity loss. • WG on Coastal and Marine Environment (AWGCWE) developed regional strategies, such as the ASEAN Regional Action Plan for Combating Marine Debris. • Declaration on the SCS; and on the Conduct of Parties in the SCS.	All SCS and GoT countries, except China, are part of ASEAN. All member countries participate in the WG and Declarations, except Malaysia and Singapore have not ratified the ASEAN Nature Agreement.
Asian Development Bank	
Its primary mission is to help its developing member countries reduce poverty and improve the quality of life for their people. The ADB provides financial means for studies and environmental initiatives at the national and regional level, and is also focussing on the concept of blue economies and sustainable livelihoods.	All SCS and GoT countries.

These mechanisms strategically leverage collaboration on less controversial issues, such as marine environmental conservation, scientific investigation, and data exchange, building a foundation for broader engagement and cooperation, and establishing trust and a track record of successful collaboration. There is also evidence of effective bilateral agreements in the SCS and GoT which focus on collaborating on specific issues: Vietnam and China have entered into the Gulf of Tonkin Fisheries Agreement that covers shared fishing areas and mandate cooperation on conservation, and the 1997 maritime boundary and resource-sharing agreement between Thailand and Vietnam, as examples (Zou & Wang 2020).

7.3. Assessing regional governance in the SCS and GoT

The World Bank Governance indicators are designed to measure governance at the national level, and whilst there is no specific measure of transboundary cooperation, the indicator for government effectiveness measures the quality of the public and civil service, policy development, government independence and commitment and thus, relates most closely to the foundational capacity and willingness of neighbouring states to ensure effective transboundary cooperation. Figure 7.3 shows the percentile ranking of countries, with Singapore, Malaysia and China leading, followed by Indonesia, Thailand and the Philippines, with Vietnam and Cambodia ranked lowest.

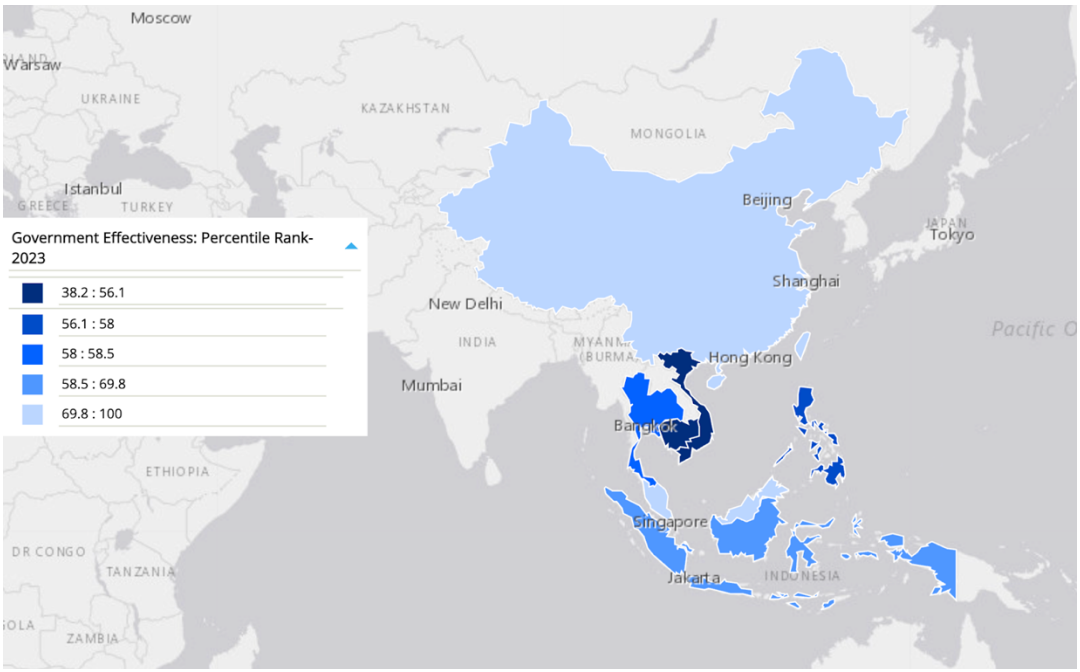


Figure 7.3 Percentile ranking of countries, with Singapore, Malaysia and China leading, followed by Indonesia, Thailand and the Philippines, with Vietnam and Cambodia lowest.

Compiled country self-assessment on national governance. As part of the **Transboundary Water Assessment Programme** (TWAP) of LMEs in 2017 an assessment of transboundary governance architecture for the SCS and GoT LMEs was undertaken using the framework of completeness, integration and engagement (Table 7.3).

Table 7-3 ***TWAP Governance Architecture Assessment Framework***

Risk Rank	Completeness Range	Integration Range	Engagement Range
Very Low	80-100%	0.8-1.0	80-100%
Low	60-80%	0.6 -0.8	60-80%
Medium	40-60%	0.4-0.6	40-60%
High	20-40%	0.2-0.4	20-40%
Very High	0-20%	0.0-0.2	0-20%

Source: Fanning *et al* 2017

Table 7-4 LMEs and National Governance Architecture Assessment

	Completeness	**Integration**	**Engagement**
SCS			
GoT			
Cambodia			
Indonesia			
Philippines			
Thailand			

In drafting the NTDA 2.0, countries also undertook a self-assessment within the national jurisdiction of the shared seas using the assessment framework (Fanning *et al* 2017), as shown in Table 7.4, which provides comparison to the risk ranking of the SCS and GoT.

Cambodia's primary risk was identified as integration (0.35-0.45), with a high-medium risk ranking, due to governance being fragmented across institutions, and sectors, despite progress with coordination mechanisms and regional cooperation. Engagement was ranked as medium (45-55%) with evidence of co-management platforms for protected fisheries and marine management areas, and formal participation in Environmental Impact Assessments (EIA), but less consistent in large scale coastal development, with improvements needed in grievance, transparency and inclusion of gender and vulnerable groups. Completeness was ranked as medium-low (55-60%) as the building blocks for governance are in place, but consistent operational implementation and enforcement capacity remains a challenge across provinces and sectors.

Indonesia's primary risks, ranked as medium, include engagement (58%) of stakeholders and integration of policies, planning and decision-making (57%). With challenges in inclusive governance for ecosystems, and fisheries and weak integration of policy and planning decision-making. Completeness was rated as very low risk (84.5%) with formal arrangements very comprehensive for inclusive governance but weaker for pollution, ecosystems, and fisheries.

The Philippines' primary risk is completeness (medium) with the need for more comprehensive and harmonised policies, a review of policies, challenges in enforcement funding, and the transboundary nature of pollution. Both integration and engagement were ranked as very low risk. However, the need to bridge local capacity and to align local policies with national, regional and international frameworks were cited as gaps.

Thailand's primary risk is integration (0.1) with a very high risk ranking due to weak cross-sectoral and multi-level coordination. However, as basic institutional and legal structures exist resulting in medium risk for completeness (50%), and relatively strong stakeholder participation resulting in a low risk for engagement (70%).

At the SCS and GoT LME level, (Fanning et al 2017) integration was ranked as a very high risk highlighting systemic challenges in harmonizing different sectors and levels of governance (local, national, and regional) across both LMEs. Generally, integration can be observed as the highest governance risk at the national and regional levels. While countries may have *internal* mechanisms for integration, this does not translate into effective integration and harmonisation *across* national borders, which remains the critical area of concern for managing the shared LMEs. Within the countries which identified integration as a lower risk, the need for improved coordination was still a key concern contributing to an effectiveness gap of national governance, and remains the principal structural weakness constraining adaptive, ecosystem-based, and transboundary governance in the SCS-GoT.

7.4. What gaps remain and what strategic actions will strengthen collaboration?

Remaining gaps. The SCS and GoT countries have ratified most of the relevant international environmental treaties to protect the shared seas but gaps remain. The lowest commitment shown across the region is to the London Convention and Protocol for the prevention of marine pollution by dumping of waste, and the prohibition of all dumping except for acceptable wastes. China, and the Philippines, have ratified all but one (relevant) treaty, and Cambodia and Vietnam are absent from four and three treaties respectively. Some treaties are more effective, such as Marpol and OCPR, than others, such as UNCLOS, and CBD which have strong frameworks but weaker implementation. There is a lack of a globally binding framework to manage land-based pollution and plastics, and illegal fishing effectively. The High Seas Treaty (BBNJ), which comes into force in January 2026, will establish MPAs in areas beyond national jurisdiction, create EIA rules and increase research funding. The RAMSAR International Convention for Wetlands and climate treaties are providing some protection to mangrove areas, for example blue carbon.

For global frameworks to be effective, and to achieve SDG14 and other ocean related SDGs regional cooperation has been flagged as critical (Mahon and Fanning 2019). Currently, there is no single legally binding agreement or regional convention for marine environmental protection in the SCS and GoT LME's which are primarily guided by soft law instruments through non-confrontational, consensus-based engagement. Integration is a significant challenge in both the SCS and GoT, and completeness also needs addressing.

Observable differences exist in collaboration within the SCS and GoT LMEs. The SCS is characterized by political sensitivity around transboundary pollution, habitat loss and degradation, and decline in fisheries biomass. Despite the GoT having a framework for transboundary cooperation, enforcement remains weak and fragmented leading to severe overfishing, ecosystem degradation and widespread transboundary pollution. For both LMEs, climate change is a risk amplifier intensifying environmental degradation and disproportionately affects the marginalized and vulnerable sectors. Tailored governance frameworks balancing economic growth, sustainability, and stability are therefore needed.

At the transboundary level, sectoral and crosscutting governance challenges exist. Regional trade (particularly energy), industrial and urban development, fisheries and logistics, and tourism are improving the economic situation of certain national and sub-national communities

through an increased regional gross domestic product, and greater financial and institutional resources, because of targeted national economic policies, such as the Eastern Economic Corridor in Thailand. However, this also intensifies pressures on coastal ecosystems through land conversion, pollution, habitat loss and overexploitation. In the Philippines, in areas such as Palawan, marine protected areas are beneficial to local communities as they attract tourism, and financial resources for effective governance, monitoring and research. Whilst remote provinces in the Philippines are identified as having limited adaptive capacity due to their socio-economic status.

Suggested strategic actions. Given the context of climate change and the current environmental, social and economic challenges faced in the SCS and GoT LMEs, proactive and collaborative governance is essential for healthy functioning ecosystem as well as to protect the livelihoods of the people who depend on them, the following strategic actions are proposed to enhance collaborative mechanisms:

- Regional collaboration must capitalise on the strengths of existing networks and platforms:
    - COBSEA is well-positioned to lead coordination efforts.
    - PEMSEA functions as a regional clearinghouse for data, community involvement, and local action.
    - ASEAN provides a high-level forum for governmental consultations; and
    - Drawing from existing partnerships there is an immediate need to establish a central and scientific knowledge sharing platform through a regional research community network in the SCS and GoT.
- Urgent action is required by all SCS-GoT countries to achieve significant progress toward SDG 14. As the 2030 deadline rapidly approaches, the window of opportunity to reverse negative trends in marine ecosystem health is narrowing. The scale of the challenges, including overfishing, marine pollution, habitat destruction, and escalating impacts of climate change, necessitates robust and comprehensive regional cooperation, as these LMEs are critical global reservoirs of marine biodiversity, supporting millions of livelihoods through fisheries and coastal tourism.
- Effective regional mechanisms, and addressing shortcomings in transboundary governance, are essential to harmonize national policies, coordinate scientific research, implement effective transboundary conservation measures, and manage shared living marine resources sustainably. This requires national commitment to regional cooperation. Only through this collective commitment can the countries of the SCS and GoT successfully address the complex, interconnected threats to their shared marine environment and ensure the realisation of SDG 14, and all other related SDGs, by 2030.
- Transformative integrated policies (social, economic and environmental) must ensure the sustainable management of the SCS and GoT is also taken into consideration, and efforts to build adaptive capacity reaches more remote and vulnerable areas, and sustainable funding is equitably distributed.
- More robust and cooperative international frameworks are needed to mitigate harm and ensure regional stability in facing the complexity and severity of the challenge of accelerating and multifaceted impacts of global climate change, to address transboundary pollution and sustainable fisheries. As BBNJ comes into force, SCS and GoT countries should work together in the establishment of a comprehensive transboundary MPA network, and not just on paper.

The ultimate aspiration for governance in the SCS and GoT is the establishment of a fully functional and effective intergovernmental regional authority, that:

- Operates within a legally binding framework, with strong commitment from all countries, to oversee and coordinate: the long-term sustainable management and protection of marine resources, critical habitats and biodiversity, endangered and migrating species, and fish refugia, the sustainable management of land based and marine pollution, industries including fisheries, aquaculture, shipping, tourism and urban and coastal development to reduce anthropogenic impacts, and respond to the amplified risks from climate change, both through reducing emissions and taking action to build climate resilience and ensure fair and just social and economic benefits for all SCS and GoT citizens.
- Serves as an institutional bridge: national and local environmental management actions are aligned with, and contribute to, fulfilling global and regional commitments, and working across disciplines to ensure integrated policies that address key transboundary environmental challenges.
- Invests in scientific research and knowledge sharing: responsible for commissioning, synthesizing, and disseminating scientific research to inform evidence-based policy and management decisions, and facilitate data sharing, and capacity building.
- Establishes mechanisms for conflict resolution and for monitoring and compliance and mediating disputes within a regional framework.

8. Synthesis and Conclusions

This Regional TDA Brief has found that using the triple planetary crises of climate change, biodiversity loss and pollution for context provides a profoundly challenging lens with which to analyze environmental changes that have taken place in the SCS-GoT region in the last 25 years. The pressures of trade and population growth were identified as major drivers of regional environmental change at the beginning of the millennium. Today, environmental governance of transboundary environmental issues (e.g. nutrient and plastics pollution, marine habitat loss and attrition, modification and climate-induced changes, overexploited fish stocks, soft-instrument based governance) is intricately bound to a shared quest for strategies that can decouple social and economic growth from degrading ecosystem vitality. This, in a region where economies span the breadth from agrarian (Cambodia) to post-industrial (Singapore), and where shared spaces are also contested grounds.

A summary of comparisons and relationships between ecosystem and social wellbeing, and wealth, gleaned from this regional analysis is fertile milieu for designing and innovating actions that transboundary environmental governance can pursue in the SCS-GoT region.

8.1. What have we learned about social wellbeing, environmental health, ecosystem vitality and wealth among countries of the SCS-GoT region?

Figure 8.1 plots 163 countries along with the eight countries of the SCS-GoT. The X axis uses the Environmental Performance Index (EPI) for 2024. The Social-Economic-Governance Index derived from the average of goal scores for SDGs 1-11, 16 and 17 in 2025, is a proxy measure of Social Wellbeing (y-axis). The coastal states of the region straddle 30 points along the EPI axis and 20 pts along the Social Wellbeing axis. The linear relationship, which is highly significant statistically mirrors the fact that social-ecological systems are indeed tightly coupled, and one shapes the other in dynamic fashion. This tight correlation means social wellbeing and ecosystem and environmental health are twin facets of the same system. A failure in environmental performance, both in protecting environmental health and in ensuring ecosystem functioning, augurs bad for social wellbeing. Policies that target only social upliftment cannot and should not forget the shared lifeblood between the two subsystems.

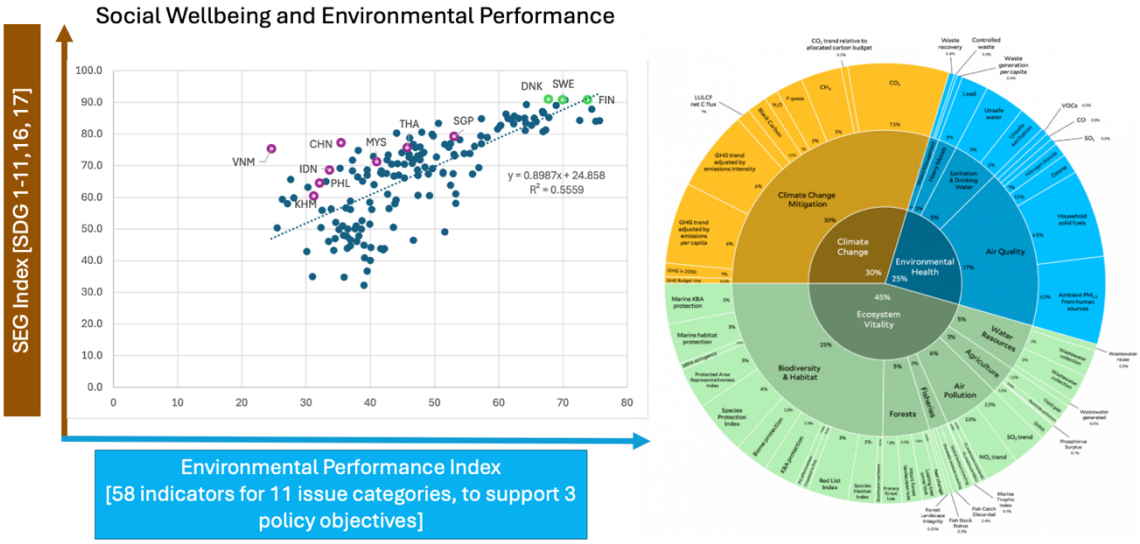


Figure 8-1 Plotting Social wellbeing defined by SDGs 1-11, 16 and 17 (Social-Economic-Governance Index using 2025 data) against the Environmental Performance Index for 2024 for 163 countries, indicate both to be correlated with high statistical significance.

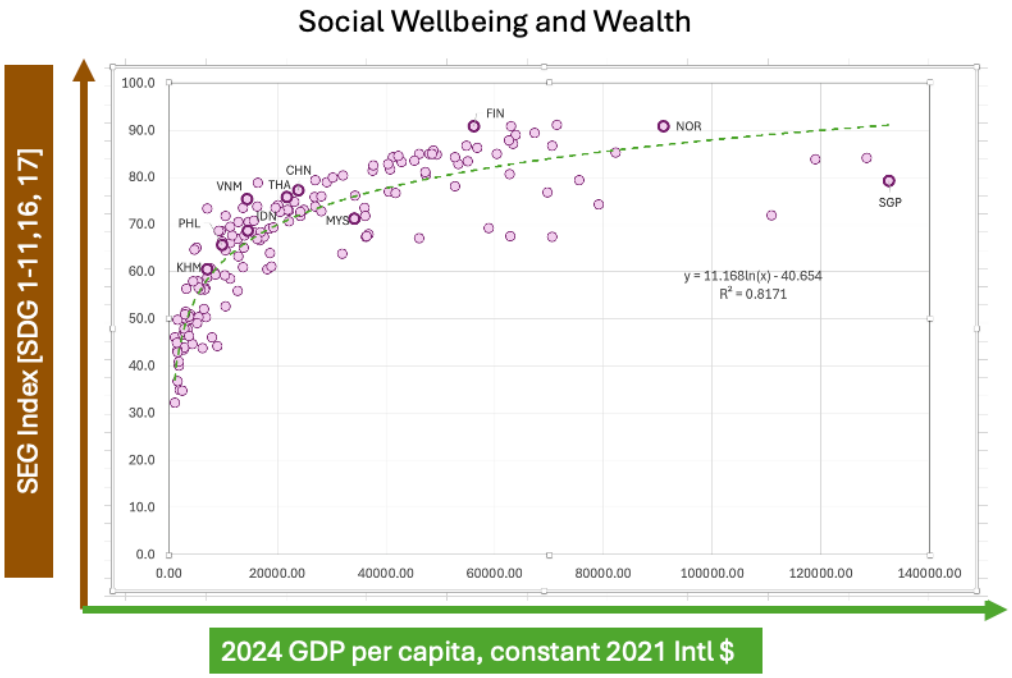


Figure 8-2 Plotting wealth using 2024 GDP per capita as proxy measure and Social Wellbeing with SEG Index as metric. The logarithmic relationship between the two is an established principle in development economics.

What about social wellbeing and wealth? These two exhibit a classic logarithmic relationship with very high statistical correlation (Figure 8-2). At survival development phase, where the slope is almost vertical, every increment in GDP growth directly reduces hunger and lengthens life expectancy, for countries like Cambodia and the Philippines, and correlation is highest. Where the slope bends, we find Indonesia, Vietnam, Thailand and China. Here, growth in wealth buys more goods but also has severe environmental impacts. Where the curve is almost flat such as where Singapore is, GDP is extremely high, but life satisfaction is not rising at the same pace. Future gains in wellbeing may come from work-life balance or tighter social cohesion, not necessarily more wealth. Given that social and ecological wellbeing are twin facets of a system, does environmental performance relate to wealth in the same fashion?

Environmental performance has two components: environmental health (e.g. pollutants hurting humans) and ecosystem vitality (humans hurting the environment). In the derivation of the Environmental Performance Index, a third component has been included, which is Climate Change (including metrics on emission and mitigation). If a metric measures environmental health, waste and anti-pollution infrastructure is something money can buy, and the relationship between environmental health and wealth can be strongly positive. If one is measuring indicators of ecosystem vitality including carbon emissions, biodiversity loss, nitrogen runoff or habitat conservation, wealth-induced consumption makes the relationship between ecosystem vitality and wealth weak or negative. The EPI measures both, weighting ecosystem vitality at 45%, environmental health at 25%, and climate change, 30%. The transparent measurement of the three components of EPI allows countries to define both qualitative and quantitative strategies and targets separately for each component so they can be judiciously tracked for progress and impacts.

Figure 8-3 hints of a logarithmic relationship between environmental performance and Wealth, but with a lot more spread among countries across the wealth span. The coastal states of the region show environmental underperformance at their respective wealth levels, even in the case of Singapore. Table 8.1 summarizes the duality between environmental health and ecosystem vitality and the governance challenges this pose at each level of development. Such duality can lead to self-cancelling interactions in terms of tracking progress. It highlights the need to understand such duality, and to institute mitigating actions to improve environmental health while at the same time implementing effective steps to protect and support ecosystem functions.

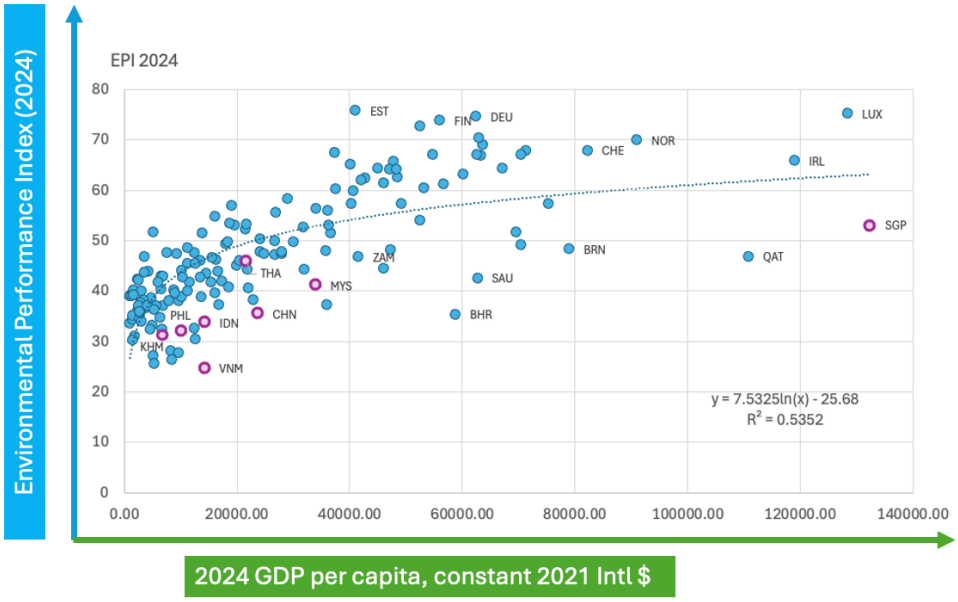


Figure 8-3 Environmental Performance and Wealth tandem hints of a logarithmic relationship but with an underlying complexity.

Table 8-1 Matrix of co-variation between wealth level, environmental health and ecosystem vitality with the resulting governance challenge.

Wealth level	**Environmental Health**	**Ecosystem Vitality**	**Governance Challenge**
Low to Mid-income (Cambodia, Philippines)	**Poor.** High disease burden from water and air	**Good.** Low carbon footprint, high biodiversity.	**Basic services:** Building sewage/water systems without destroying the ecosystem base
Middle to High income (Vietnam)	**Improving.** Sanitation gets better	**Collapsing.** Rapid industrialization destroys rivers/ air/ forests.	**The Pivot:** Stopping the "grow dirty, clean up later" mentality before damage is irreversible.
Very High income (Singapore)	**Excellent.** Almost no environmental disease.	**Struggling.** High consumption, waste generation, and CO_2 emissions	**Lifestyle Change:** Shifting from efficiency (doing bad things better) to sufficiency (doing fewer bad things.)

8.2. How do we leverage the diversity in social, environmental and wealth capital among SCS-GoT coastal states towards effective transborder environmental governance?

A foundational pillar of international law is the principle of "Common but Differentiated Responsibilities". It provides guidance on how to bring actors toward common goals despite their differences in circumstance, capacities and culture. The same strategic principle guides the UN Climate Convention Framework in determining the obligations of industrialized, industrializing and agrarian economies relative to their emission rates, carbon credits and taxes, climate fund allocation, among others.

In the SCS-Got, the disparities in levels of social wellbeing, economic development and wealth among its coastal states represent opportunities to innovate on an experimental set of terms of engagement. A country's historical contexts, policy choices, and legislative frameworks become learning platforms on how triple bottom lines (environmental protection, social justice and economic development) may best be achieved across multiple national scenarios. The principle of "Common but Differentiated Opportunity" can engage participating countries, cognizant that wealthy nations have big historic footprints, while developing nations have ecological assets, and they can interact in support of each other's weaknesses and strengths. Innovative interactions targeting major transboundary concerns are outlined below in broad strokes:

- **On climate governance**, the ASEAN-China Green Industrial Pact may go beyond just setting targets. It can build the ASEAN Power Grid with the premise that the grid gives priority access to renewable sources over coal. This forces the market to decarbonize without a carbon tax that poorer nations cannot yet afford.
- **On biodiversity governance**, a regional governance body can turn "Biodiversity" into an export product, so that richer countries can provide eco-compensation to poorer ones. "Ecosystem Vitality Funds" for transboundary systems like the South China Sea, the Gulf of Thailand, and the Mekong River, may then be established and payments by richer members are made in exchange for ecosystems preserved and protected by less wealthy but natural resource-rich countries.
- **On pollution governance**, a regional body develops a harmonized "Green Taxonomy" (already initiated by ASEAN). If a beneficiary bank lends money to a factory in Vietnam, for example, that factory must meet the beneficiary country's higher emission standards. If not, the deal can become ineligible for regional insurance or preferential trade tariffs under the Regional Comprehensive Economic Partnership, a mechanism to prevent a race to the bottom.
- Building on the legacy of non-interference, the governance architecture can use **transparency** as its guiding operational standard, not fines. Make data public, including calling and shaming errant parties to force local governments to be compliant so as not to lose face.
- **A blended finance facility** through the Asian Development Bank +AllB can be established as a "**Just Transition Facility**" allowing coal plants for example to transition to renewables, financing transition projects as "Amber" projects.
- A neatly outlined vision on environmental governance presented in Section 7 (Knight 2026) provides a fertile platform for dialogue among participating countries.

8.3. What concrete actions can be taken while designing new forms of engagement?

Table 8.1 presents a preliminary summary of regional actions proposed in this regional brief. This compilation remains to be vetted by participating countries during the Strategic Action Planning phase. Those identified as priority actions can be further analyzed using economic methods that employ Net Benefit Valuation, including costs of inaction. Because two more national reports remain in the process of completion, a summary of actions is envisioned to be updated soon.

Table 8-2 Summary of transboundary issues and proposed regional actions to address these

Recommended Regional Actions Across Six Thematic Areas in the South China Sea and the Gulf of Thailand

A. Climate Change Adaptation

Sub-theme	Key Recommended Actions	Implementation Focus & Notes
	Establish Integrated Early Warning Systems (EWS) with community preparedness	Involve communities and achieve benefit-to-cost ratio >10 (Krishnan et al. 2025)
	Expand decentralized renewable energy systems (solar, wind)	Ensure post-disaster energy supply and increase community resilience (WRI 2025)
	Promote sustainable agriculture & land use (agroforestry, silvopasture, community forests)	Reduce land-use emissions (20% of GHG); enhance farmer resilience
	Invest in climate-smart buildings (passive cooling, reflective roofs, low-carbon materials)	Decrease building emissions (20% of GHG); provide co-benefits
	Expand urban green spaces	Lower ambient temperature through shading and evapotranspiration
	Protect & restore coastal ecosystems (mangroves, seagrass, coral)	Provide carbon sequestration, fisheries support, and natural flood defense
	Build stormwater drainage networks & detention basins	Reduce urban flooding; land-intensive (may not suit dense urban areas)
	Implement "soft" shoreline maintenance & flexible infrastructure planning	Use dunes, vegetation, setbacks; implement dynamic planning to reduce long-term risk (Feng et al. 2025)

B. Socioeconomic & Livelihoods

Sub-theme	Key Recommended Actions	Implementation Focus & Notes
	Promote gender equality in environmental governance	Empower women to assume leadership roles: habitat restoration, sustainable fishing, plastic waste initiatives, climate-friendly consumption
	Poverty alleviation through cash transfer programs & vocational training	Build on Indonesia/Philippines models; youth training in digital monitoring, citizen science, climate outreach
	Ensure inclusive community participation in decision-making	Enable vulnerable groups to participate in environmental governance & solution design

C. Pollution Control

Sub-theme	Key Recommended Actions	Implementation Focus & Notes
	Update SAP priorities for 2030 and 2050	Reflect rising plastic leakage and stronger climate and storm pressures.
	Adopt a regional legally binding pollution framework	Build on existing regional instruments and agree on shared targets and obligations.
	Invest in land-based pollution control for coastal cities	Package wastewater and solid-waste upgrades; prioritize hotspots and high-exposure cities.
	Climate-proof waste and wastewater systems	Storm-safe design, redundancy, overflow controls, safer siting; align with land-use planning and marine spatial planning.
	Build a regional Monitoring Review Verification (MRV) and performance scorecard	Shared indicators and reporting; data platform for tracking delivery and benchmarking progress.

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	Reduce nutrient loads in priority watersheds	Reform fertilizer incentives; scale precision nutrient management and farmer advisory support.
	Align plastics measures and EPR across the region	Common standards and coordinated action plans; comparable data and scenario tools to guide choices.

D. Marine Habitats & Ecosystems

Sub-theme	Key Recommended Actions	Implementation Focus & Notes
	Manage biodiversity hotspots with locally appropriate restoration & management	Customize actions to habitat status, impacts, and resilience
	Develop & connect MPA & OECM networks	Improve management effectiveness and ecological connectivity
	Protect migratory species across nesting/feeding areas	Exchange information and conservation techniques, reduce bycatch
	Enhance climate resilience & reduce cumulative anthropogenic impacts	Plan for scenarios that feature unpredictable events
	Strengthen monitoring, evaluation, reporting & policy briefing	Enable adaptive management
	Promote transboundary cooperation (habitats, fisheries refugia, blue carbon, pollution, migratory species)	Encourage and support multi-theme, cross-border collaboration

E. Sustainable Fisheries Management

Sub-theme	Key Recommended Actions	Implementation Focus & Notes
	**Gulf of Thailand (Recovery Challenge):** Drastically reduce fishing capacity (especially bottom trawlers) and enhance bilateral cooperation and enforcement	• Adopt Ecosystem-Based Fisheries Management (EBFM) • Eliminate Illegal, Unregulated and Unreported (IUU) fishing • Strengthen Monitoring Control and Surveillance (MCS) systems • Invest in shared science & stock assessment. • Phase out harmful subsidies • Promote sustainable aquaculture
	**South China Sea (Prevention Challenge):** Establish Regional Fisheries Management Organization (RFMO); set shared TACs; protect spawning grounds	

F. Governance and Collaboration

Sub-theme	Key Recommended Actions	Implementation Focus & Notes
	Strengthen existing platforms:	COBSEA (coordination), PEMSEA (data/community), ASEAN (policy dialogue), regional research networks
	Accelerate progress toward UNSDG 14 by 2030	Reverse trends in overfishing, pollution, habitat loss, climate impacts
	Establish effective transboundary governance mechanisms	Harmonize policies, coordinate science, implement cross-border conservation
	Ensure integrated, equitable policies & funding	Reach remote/vulnerable communities; distribute resources fairly
	Long-term vision: Create a fully functional intergovernmental regional authority for SCS & GoT	Apex body for integrated marine governance

ANNEX 1. DRAFT NATIONAL ACTION PLANS

National Recommended Actions to Mitigate Transboundary Environmental & Shared Socio-economic Issues in the South China Sea and Gulf of Thailand

A DRAFT COMPILATION BASED ON NATIONAL TRANSBOUNDARY ANALYSES REPORTS BY CAMBODIA, INDONESIA, PHILIPPINES, THAILAND AND VIETNAM

Project TDA-SAP TEAM
SCS SAP PCU

SCS SAP

UN environment programme

gef

UNOPS

National Recommended Actions on Socioeconomics and Climate Vulnerability

Thematic Area	Cambodia	Indonesia	Philippines	Thailand
 **Infrastructure & Nature-Based Solutions (NbS)**	– Implement risk-informed urban/port resilience (drainage, floodproofing). – Restore mangroves, dunes, and reefs as natural defenses. – Scale small/medium-scale water storage and salinity barriers.	– Strengthen adaptive infrastructure (mangrove restoration, seawalls, coastal rehabilitation). – Implement landscape-scale mangrove restoration programs.	– Promote the use of Nature-Based Solutions (NbS) alongside grey infrastructure (e.g., constructed wetlands, mangrove/coral rehabilitation). – Integrate local ecological knowledge into technology and innovation.	– Implement differentiated, area-based adaptation (e.g., climate-proofing for high-intensity zones, large-scale EbA like mangrove restoration for high-magnitude zones). – Prioritize soft infrastructure and ecosystem-based adaptation (EbA).
 **Economic Diversification & Livelihoods**	– Promote inclusive human development and livelihoods (invest in education, health, MSME diversification linked to tourism/ports). – Strengthen migrant inclusion in disaster systems.	– Economic empowerment through livelihood diversification (aquaculture training, ecotourism, value-added marine products). – Develop coastal economic diversification programs (fisheries enterprises, agro-marine businesses).	– Align blue economy potential with science, technology, and innovation (STI) and infrastructure development. – Create growth centers focused on the blue economy.	– (Implied in protecting resource bases that sustain local economies via EbA and spatial planning).
 **Early Warning Systems & Data Integration**	– Establish joint protocols for cross-border early warning and dam-release schedules. – Run compound-risk drills with ports and municipalities.	– Deploy enhanced Early Warning Systems (EWS) with buoys, radars, and real-time monitoring. – Integrate climate data (SLR, storms) into regional and local spatial plans (RTRW, RPJMD).	– Invest in research to provide up-to-date baseline data for monitoring and evaluation. – Utilize social media for promotion and organized tracking of environmental fees.	– Enhance regional early warning systems through improved data sharing and technical cooperation (ASEAN, typhoon committees). – Apply advanced risk assessment models and incorporate ocean literacy as a vulnerability indicator.

Thematic Area	Cambodia	Indonesia	Philippines	Thailand
 **Community Empowerment & Capacity Building**	– (Implied in livelihood and migrant inclusion actions)	– (Implied in economic empowerment and EWS deployment)	– Invest in sustained, inclusive capacity-building across sectors (seminars, workshops). – Provide incentives (e.g., groceries, medicines) to motivate community participation. – Form trained community enforcement groups (Bantay-Dagat/Bantay-Gubat).	– (Focus is on systemic governance and financing; community action is implied through risk awareness and preparedness).
 **Governance, Finance & Policy Support**	– Enforce building codes, land-use setbacks, and continuity plans. – Maintain shock-responsive cash transfers (ID-Poor) for vulnerable households.	– Implement sustainable adaptation financing schemes (revolving funds, micro-financing).	– Strengthen legislative-executive support for sustainable efforts and green initiatives. – Offer rewards for public participation (e.g., rice for plastic, tax reductions). – Strengthen corporate social responsibility (CSR) with strict monitoring and sanctions.	– **Mainstream proactive risk governance:**Shift budget priorities from post-disaster relief to pre-disaster mitigation and climate adaptation. – Integrate climate risk into national (13th NESDP) and provincial planning and budgeting
 **Regional Cooperation**	– Strengthen regional cooperation in the Gulf of Thailand & Mekong: share hydro-meteorological data, align pollution controls, coordinate fisheries management and blue-tourism standards.	– Establish a shared regional climate data repository. – Facilitate technical collaboration and best-practice exchange for mangrove restoration. – Create joint markets and branding for regional coastal products.	– Increase network-building and partnerships through regular multi-stakeholder meetings and conferences. – Involve all development sectors to tackle root causes and mobilize funding and labor resources.	– Strengthen transboundary cooperation on shared threats (typhoons, tsunamis, droughts, marine pollution, oil spills). – Establish regional frameworks for managing shared marine ecosystems and fisheries.

Thematic Area	Cambodia	Indonesia	Philippines	Thailand
		– Deploy shared sensor networks for real-time data exchange.		– Develop joint strategies to access international climate finance and technology

National Recommended Actions for Marine Pollution Management

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Infrastructure & Waste Management**	- Accelerate sanitation/ WWTP investments in capital and coastal towns. - Improve coastal waste collection and upgrade dumps to controlled landfills. - Scale up Sihanoukville marine-litter pilots to national level.	-Develop and maintain solid-waste and sanitary infrastructure at the local level.	- Invest in wastewater treatment and resource-recovery facilities. - Improve waste collection and support recycling markets. - Implement circular-economy and nature-based solutions.	- Enhance waste-collection systems in coastal/rural areas. - Accelerate Extended Producer Responsibility (EPR) schemes. - Establish regional plastic-waste trading mechanisms.	– Systematic investment in wastewater treatment, solid waste management, and pollution monitoring infrastructure across all assessed provinces – Investment in advanced pollution control technologies, digital management systems, and nature-based solutions
	- Prioritize inspections where RQ > 1; link permit renewals to verified WWTP performance. - Require ports (PAS/PPAP) to report annual oily-	-Coordinate national and local agencies to combat oil-sludge and plastic pollution.	- Expand real-time monitoring in pollution hotspots. - Enforce heavier penalties and train enforcement units.	- Strengthen inter-agency coordination. - Implement graduated penalty systems for violations. - Enhance monitoring and compliance systems.	– Strengthened environmental law enforcement, – enhanced penalties, – improved compliance monitoring systems

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
Monitoring, Enforcement & Regulation	waste/hazardous-waste reception. - Strengthen hazardous-waste handling via the Kampot co-processing facility and Basel-aligned manifest systems.		- Harmonize pollution standards with ASEAN.		
 **Policy, Planning & Economic Instruments**	- Clarify mandates under the 2023 Environmental Code; strengthen enforcement roles. - Establish a coastal/marine pollution fund (national budget + environmental fees + blue economy/ climate finance). - Implement EPR for plastics, DRS systems and tourism-area bag levies. - Implement nutrient-management plans in agricultural catchments (buffer strips, fertilizer budgeting).	-(Primarily focused on coordination and infrastructure)	- Establish a national oceans policy. - Implement sustainable financing and public-private partnerships.	- Implement regional carbon-pricing and pollution-trading systems. - Develop green-bond markets for infrastructure. - Align national standards with regional benchmarks.	- Immediate intervention in critical pollution hotspots including Ninh Thuan coastal dumping, Ho Chi Minh City riverine pollution, and Hai Phong industrial contamination

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Ecosystem Protection & Restoration**	- Designate pollution-control zones with stricter limits and restoration of mangroves, seagrass and wetlands. - Develop a Cambodia–Gulf of Thailand “blue corridor” connecting key MPAs across the region.	- Coordinate with the tourism sector to mitigate impacts of stranded oil sludge.	- Protect sensitive ecosystems (e.g., MPAs with high water quality). - Launch habitat-restoration projects. - Integrate ridge-to-reef watershed management.	- Implement integrated coastal zone management (ICZM). - Establish transboundary MPA networks. - Develop regional ecosystem-restoration programs.	- (Implied in environmental protection)
 **Community Engagement & Awareness**	- Provide targeted measures for high-exposure communities: safer water, shellfish advisories, livelihood support. - Use tourism-area instruments (e.g., bag levies) to shift behavior and reduce leakage.	- Implement community-awareness programs on waste reduction, hygienic living, and fishing gear retrieval.	- Strengthen education campaigns and community-based programs. - Involve fisherfolk in monitoring. - Establish a civil-society platform.	- (Implied in capacity building and technology transfer)	- Sustained public engagement, education, and participation in pollution management and environmental protection.
 **Regional Cooperation & Contingency**	- Launch joint monitoring with Thailand and Viet Nam for Gulf of Thailand and transboundary estuaries. - Develop a Cambodia–Viet Nam wastewater initiative for Mekong–Bassac hot spots.	- Coordinate regional efforts on oil pollution and marine debris control through ASEAN.	- Establish a regional contingency plan for spill response. - Operationalize ASEAN disaster mechanisms. - Organize an ASEAN Coastal Cleanup Day.	- Establish harmonized monitoring protocols with ASEAN. - Create joint early-warning systems for pollution incidents. - Facilitate knowledge sharing and joint R&D.	- Enhanced cooperation between provinces for transboundary pollution management and resource sharing. - Continued cooperation with multilateral organizations,

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
	- Form a Gulf of Thailand marine-litter partnership with Thailand and Viet Nam. - Develop a national oil-spill contingency plan with joint drills involving Thailand and Viet Nam.				bilateral partners, and private sector for technology transfer and financing.
 **Research, Data & Innovation**	- Establish a unified national pollution database integrating MoE, FiA, MRC and JICA-linked datasets. - Apply routine RQ/WQI scoring for hotspots (Prek Toeuk Sap, Kampot, Kep, Tatai–Koh Kong, Phnom Penh). - Add pesticides, microplastics and AMR markers to selected stations.	-(Focus on local implementation rather than explicit R&D)	- Strengthen long-term monitoring of emerging contaminants. - Promote open-data governance. - Invest in pollution-control technologies.	- Develop next-generation pollution-monitoring technologies. - Promote biodegradable alternatives and circular supply chains. - Promote joint research and development initiatives.	- (Focus on Technology Advancement)

National Recommended Actions for the Marine Ecosystem

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Governance & Policy**	- Revise laws with ICZM provisions; - Adopt a National Coastal and Marine Policy; - Enact Marine Spatial Planning (MSP) regulations.	- Clarify mandates; establish joint coordinating bodies; - Harmonize legal instruments; - Operationalize the One Map Policy.	- Strengthen legal and institutional frameworks for ecosystem-based management across entire seascapes.	- Adopt ecosystem-based and climate-informed planning; - Mainstream MSP and Ocean Accounts; - Integrate biodiversity into EIAs and SEAs.	- IZCM approaches should integrate multiple habitat types and consider ecosystem connectivity.
 **Institutional Capacity & Coordination**	- Formalize an inter-ministerial ICZM mechanism; - Strengthen decentralization; - Support Community Fisheries (CFis) with legal recognition and training.	- Strengthen co-management; - Empower community-based fire prevention; integrate Ministry of Environment and Forestry (KLHK) with Ministry of Marine Affairs and Fisheries (KKP).	- Engage local communities in enforcement and stewardship; - Empower local stakeholders in monitoring and compliance.	- Institutionalize participatory co-management frameworks; - Link communities, tourism, and fishers with national agencies; - Empower women and youth.	- Strengthen Provincial coordination mechanisms to ensure consistent protection standards. - Requires: Technical training programs, Benefit-sharing mechanisms, and Local capacity building
 **Data, Research & Technology**	- Create a national coastal-marine data centre; - Expand long-term monitoring; - Invest in remote sensing, drones, and VMS/e-CDT for fisheries.	- Build integrated monitoring systems; improve scientific bases for mangrove restoration and site selection; - Advance "Hydrology-First" wetland restoration.	- Standardize monitoring protocols for corals, seagrass, mangroves, and key wildlife across the country and SCS region.	- Develop a centralized marine and coastal information platform; - Strengthen research on blue carbon, genetic restoration, and AI-based tools.	- Scientific research enhancement, focus on: Genetic diversity conservation, ecosystem restoration techniques, · climate change vulnerability assessments and Sustainable use guidelines

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Sustainable Financing**	- Implement MPA user fees, - Payment for ecosystem services, and blue-carbon finance; - Blend public-private investment for waste infrastructure.	- Develop finance and market mechanisms; - Mobilize sustainable finance; - Secure funding for long-term monitoring.	- (Implicit in community capacity-building and MPA expansion, though not explicitly detailed in provided text).	- Mobilize finance via Green Climate Fund (GCF) and public-private partnerships; - Integrate natural capital accounting into national planning.	- (Implicit in community capacity-building)
 **Enforcement & Compliance**	- Increase resources for patrols; - Adopt graduated penalties and case tracking; - Roll out VMS/e-CDT; enable community co-enforcement.	- (Implicit in strengthened spatial governance and co-management).	- Continue investing in community-based enforcement and capacity-building.	- (Implicit in co-management and policy integration).	- Sharing a good practices on community engagement in habitat management from Thai Binh and Can Gio demonstrate sites.
 **Ecosystem Restoration & NbS**	- Mainstream ecosystem-based adaptation (mangrove restoration, reef/seagrass protection); - Diversify livelihoods (climate-smart aquaculture, eco-tourism).	- Improve mangrove restoration quality; - Advance post-mining rehabilitation for coral reefs; - Promote low-impact marine tourism.	- Integrate climate adaptation into reef and seagrass management to maintain resilience.	- Scale up large-scale restoration of mangroves, corals, and seagrass; - Promote blue-carbon initiatives; - Integrate NbS into national adaptation.	- Scaling up community-based approaches in habitat management.

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Regional & Transboundary Cooperation**	- Pursue bilateral agreements with Viet Nam/Thailand on stocks and IUU; - Participate in ASEAN/COBSEA networks; share data via PEMSEA/ SEAFDEC.	- Create an SCS Mangrove Corridor; - Launch a joint pollution mitigation program; - Establish an SCS R&D Fund; - Implement CTI-CFF RPOA 2.0.	- Enhance cooperation under the SCS-SAP to address shared threats and sustain ecological connectivity.	- Deepen collaboration with ASEAN and SCS-SAP; - Establish regional early-warning systems; - Encourage joint restoration and cross-border research.	

National Recommended Actions for Sustainable Fisheries Management

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Stock Management & Sustainable Harvest**	- Complete vessel registration. - Cap/Reduce trawl & purse-seine effort. - Enforce trawl-free zones & seasonal closures. - Mandate sustainable gear technologies. - Establish quantitative management targets.	- Promote ecosystem-based fisheries management to minimize bycatch. - Raise awareness on harmful gear impacts.	- Develop Harvest Strategies with reference points. - Assess fishing capacity. - Manage conflicts between fisheries & aquaculture. - Promote sustainable aquaculture development.	- Integrate primary production data to refine MSY estimates. - Conduct single-species assessments for key vulnerable/important species. - Establish a reference point for trash fish catch from trawls.	- Immediate Implementation of fishing effort reduction measures through coordinated provincial and national action.

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Governance, Enforcement & Compliance**	- Scale up Monitoring, Control, and Surveillance (MCS). - Upgrade fisheries data systems (FIMS). - Reform fisheries subsidies. - Empower Community Fisheries (CFi). - Mainstream gender and social inclusion.	- Strengthen MCS via technology and port-state measures. - Ensure enforcement of spatial planning laws ("RZWP3K"). - Improve traceability & catch documentation systems (CDS).	- Enhance fisheries surveillance & enforcement. - Support community-based surveillance groups. - Establish a traceability system for capture fisheries.	- Develop a differentiated management plan for Small-Scale Fisheries (SSF) aligned with FAO guidelines. - Monitor "effort creep" (increased fishing efficiency) beyond just fishing days.	- Stakeholder Engagement ensuring fishing communities remain central to management decisions while supporting their transition to sustainable practices
 **Habitat Protection & Climate Resilience**	- Restore and conserve critical habitats (mangroves, seagrass, coral reefs). - Integrate climate projections into harvest rules & aquaculture zoning. - Control land- and sea-based pollution. - Enhance biomass and CPUE trend monitoring.	- Combat degradation of benthic habitats from gear (e.g., ALDFG). - Promote responsible fishing practices to protect habitats.	- Establish MPAs and Marine Peace Parks. - Conduct habitat assessments and evaluations.	- Implement area-based conservation with gear restrictions in critical nursing/spawning grounds. - Incorporate ecosystem indicators and reference points into management plans. - Accelerate transition to selective gears and incentivize bycatch reduction devices.	- Adaptive Management approaches that enable flexible responses to changing environmental and market conditions.

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
 **Science, Data & Technology**	- Collaborative climate and ecosystem research with neighbors.	- Enhance water quality monitoring and disease surveillance in aquaculture.	- Conduct stock assessments for vulnerable species. - Translate scientific advice into policy. - Standardize data and promote sharing. - Leverage Marine Scientific Research (MSR) for national policies.	- Retrieve and digitize historical data for long-term productivity baselines. - Apply indicators like LB-SPR and Yield-Per-Recruit for single-species assessment.	- Technology adoption to maintain economic growth while reducing wild stock pressure.
 **Aquaculture Management**	- (Integrated into climate zoning and pollution control)	- Promote good practices for sustainable aquaculture. - Promote sustainable, plant-based feeds. - Enhance access to quality seed stock and technology.	- Promote sustainable aquaculture development. - Manage conflicts with capture fisheries.	- (Implicit in ecosystem and habitat management)	- Sustained Investment in aquaculture development, processing capacity,
 **Socio-Economic Resilience & Livelihoods**	- Empower Community Fisheries (CFi) and co-management bodies.	- Promote sustainable livelihood alternatives for coastal communities.	- (Implicit in community-based surveillance and conflict management)	- (Implicit in SSF management plan development)	- (Implicit in engagements of stakeholders in management decisions)

Thematic Area	Cambodia	Indonesia	Philippines	Thailand	Vietnam
Regional & Transboundary Cooperation	- Joint stock assessments for shared species. - Harmonize gear regulations and mesh-size standards. - Establish a shared IUU vessel information system. - Explore cooperative fleet effort-reduction. - Joint habitat-protection initiatives (e.g., MPAs, mangrove corridors).	- (Focus is primarily on national enforcement against illegal cross-border trade and IUU)	- Establish a Regional Fishery Management Organization (RFMO). - Establish a Fisheries Science Working Group. - Establish MPAs and Marine Peace Parks.	- Establish joint management plans for transboundary species (e.g., neritic tunas, mackerels). - Leverage the GoTFish Project to harmonize assessment methods and data sharing. - Develop regional plans including joint TACs and harmonized adaptive closed seasons.	- Enhanced Cooperation between provinces, research institutions, and international partners to address transboundary challenges and share best practices.

National Recommended Actions for Governance

Thematic Area	Cambodia	Indonesia	Philippines	Thailand
 **Institutional & Legal Frameworks**	- Finalize foundational marine governance (NCCMD sub-decree, MSP for EEZ). - Ratify UNCLOS domestically. - Integrate climate risk into planning.	- Establish a multi-level (central-provincial-regency) governance framework for the blue economy.	- Strengthen consistent policy implementation and inter-agency coordination. - Integrate fisheries and coastal management at the national level. - Harmonize policies across different government levels.	- Improve cross-sectoral and multi-level coordination among national agencies and provinces. - Enhance legal coherence (e.g., finalize Climate Change Act, align with existing laws).
 **Enforcement, Compliance & Local Capacity**	- Scale up MFMAs/MPAs with secured patrol and O&M funding. - Embed SMART monitoring into adaptive fisheries management. - Empower Community Fisheries (CFis).	- Strengthen eradication of illegal fishing through enhanced monitoring, enforcement, and regional cooperation.	- Improve local government enforcement, compliance, and coordination by building capacity and resources. - Remove political interference and allow financial autonomy for LGUs.	- Strengthen provincial implementation capacity (staffing, resources, training). - Enhance mechanisms for inclusive stakeholder participation (fishers, women, communities).
 **Sustainable Financing**	- Finance the blue transition via blue/green bonds, PPPs, and climate funds. - Create a Coastal Co-management Fund. - Establish a Blue Public Investment Program (BPIP).	- (Implied in framework development)	- Ensure sustainable financing for governance measures.	- Mobilize sustainable financing via domestic budgets, climate funds, blue carbon, and blended finance.

Thematic Area	Cambodia	Indonesia	Philippines	Thailand
 **Pollution & Waste Management**	- Operationalize RAP MALI through EPR pilots for plastics. - Strengthen wastewater/ solid-waste systems. - Upgrade environmental management at port.	- Create a dedicated regional platform for managing marine plastic debris and ALDFG.	- (Covered in dedicated pollution document)	- Strengthen pollution control as part of ecosystem protection.
 **Data, Science & Monitoring**	- Institutionalize open marine data across agencies. - Integrate land-sea datasets for planning. - Ensure periodic review and evaluation.	- (Focus on enforcement and coordination)	- Improve data collection, reporting, and monitoring to assess policy effectiveness.	- Strengthen data integration and science-policy linkages via interoperable systems and research collaboration.
 **Risk Management & Climate Resilience**	- Strengthen oil-spill preparedness (National Contingency Plan, sensitivity atlas). - Integrate NDC and nature-based solutions into provincial plans.	- (Implied in ecosystem conservation focus)	- Anchor regional cooperation on Biodiversity, Climate targets, and SDGs.	- Accelerate ecosystem protection and climate-resilient management (restoration, NbS). - Integrate climate risk into local planning.

Thematic Area	Cambodia	Indonesia	Philippines	Thailand
Regional & Transboundary Cooperation	- Strengthen Gulf of Thailand coordination (joint exercises, stock assessments). - Expand Mekong water governance. - Align with global frameworks (BBNJ, PEMSEA, IMO).	- Revitalize ASEAN working groups on transboundary pollution. - Enhance SCS working groups on coastal ecosystem conservation.	- Use the Strategic Action Programme as a basis for regional cooperation aligned with global targets.	- Deepen regional engagement via ASEAN, COBSEA, PEMSEA, etc., for pollution monitoring, shared stocks, and early-warning systems.