Scoping Report

Thailand's
National Ecosystem Assessment

January 2024

OFFICE OF NATURAL RESOURCES AND ENVIRONMENTAL POLICY AND PLANNING

ศูนย์บริการวิชาการแห่งจุฬาลงกรณ์มหาวิทยาลัย
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This report has been produced by Chulalongkorn University, as part of the Biodiversity and Ecosystem Services Network (BES-Net) Phase II project with technical support from the National Ecosystem Assessment (NEA) Initiative at the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). Financial support was provided by the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of the Federal Republic of Germany and SwedBio at Stockholm Resilience Centre.

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Acknowledgements
The Office of Natural Resources and Environmental Policy and Planning (ONEP), and Chulalongkorn University, would like to thank all partners and stakeholders for their valuable support during the scoping stage of the Thailand National Ecosystem Assessment, which culminated with the production of this report. We are particularly grateful to the Department of Marine and Coastal Resources (DMCR) and the Department of National Parks, Wildlife and Plant Conservation (DNP). Support from UNEP-WCMC, UNESCO and UNDP from the BES-Net consortium is also acknowledged with much gratitude.

This report has benefited deeply from the inputs of Thailand's ethnic and local communities, and members of the academic community. The preparation of the report would not have been possible without their close collaboration and engagement.

We extend our sincere gratitude for the financial support from IKI of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of the Federal Republic of Germany and SwedBio at Stockholm Resilience Centre.

List of Acronyms

BOB	Bay of Bengal
BOI	Board of Investments
BEDO	Biodiversity- Based Economy Development Office
BES	Biodiversity and Ecosystem Services
CBD	Convention on Biological Diversity
CPUE	Catch Per Unit Effort
Chevron	Chevron Thailand Exploration and Production, Ltd.
CSR	Corporate Social Responsibility
COP	Conference of the Parties
DASTA	Designated Areas for Sustainable Tourism Administration
DCCE	Department of Climate Change and Environment
DDPM	Department of Disaster Prevention and Mitigation
DEDE	Department of Alternative Energy Development and Efficiency
DMCR	Department of Marine and Coastal Resources
DMF	Department of Mineral Fuels
DOF	Department of Fisheries
DNP	Department of National Parks, Wildlife and Plant Conservation
DPT	Department of Public Works and Town & Country Planning
DIT	Department of Internal trade
DBD	Department of Business Development
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
GDP	Gross domestic product
GoT	Gulf of Thailand
ILK	Indigenous and local knowledge
IPLCs	Indigenous Peoples and Local Communities
IPBES	The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
MOE	Ministry of Education

MDGs	Millennium Development Goals
MOC	Ministry of Commerce
MOTS	Ministry of Tourism and Sports
MSY	Maximum sustainable yield
MNRE	Ministry Of Natural Resources and Environment
MPAs	Marine Protected Areas
MWTP	Mean Willingness to Pay
NCP	Nature's contributions to people
NESDB	Office of the National Economic and Social Development Board
NSO	National Statistical Office
NSOCR	National State of the Oceans and Coasts Report of Thailand
NEA	National Ecosystem Assessment
MFF	The Mangroves for the Future
ONEP	Office of Natural Resources and Environmental Policy and Planning
OECMs	Other Effective area-based Conservation Measures
PAT	Port of Authority of Thailand
PCD	Pollution Control Department
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PTTEP	PTT Exploration and Production Public Company Limited
PTIT	Petroleum Institute of Thailand
PES	Payment for Ecosystem Services
SDF	Sustainable Development Foundation
SAKM	Sub-committee for advice and knowledge management for the national maritime interests
TAT	Tourism Authority of Thailand
TEI	Thailand Environment Institute
TEV	Total Economic Value
UNEP-WCMC	United Nations Environmental Programme -World Conservation Monitoring Centre
TCM	Travel Cost Method

WWF	World Wildlife Fund

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Chapter 1. Introduction

Thailand became a Contracting Party to the Convention on Biological Diversity (CBD) in 2004 and committed to the conservation and sustainable use of biological diversity. The CBD COP Decision14/1 urged and called on all Parties to undertake national assessments of biodiversity and ecosystem functions and services to recognize values and the contribution of biodiversity and ecosystem services across sectors and design plans and strategies for biodiversity management. The assessment should analyze the contributions of biodiversity and ecosystem services to the implementation of the Sustainable Development Goals (SDGs), recognizing synergies and trade-offs associated with meeting multiple goals, and the need for balanced integration between the social, economic, and environmental dimensions of sustainable development. This report aims to identify data sources and set out key policy questions, as well as outline how ecosystem assessments and their related values can be undertaken and support the uptake of assessment findings into national decision making.

The United Nations Environment Programme World Conservation Monitoring Centre's (UNEP-WCMC) National Ecosystem Assessment Initiative has supported 14 countries in conducting or scoping their national ecosystem assessments. Thailand formally joined the Initiative in April 2021, together with Botswana, the Dominican Republic, and Malawi, and the project will run until September 2026. The assessment process has been divided into four stages: Scoping, Expert Evaluation, Approval, and Dissemination and Use of the Assessment Findings. The assessment will assess the state of knowledge on past, present and future interactions between people and nature, including by highlighting thresholds, feedback, synergies, and trade-offs. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) framework (Diaz et al., 2015) has been used as a guidance and as a key item integrated with other tools for improving the capabilities of the science-policy interface and achieving the project's goals.

In Thailand, the Office of Natural Resources and Environmental Policy and Planning (ONEP) under the Ministry of Natural Resources and Environment (MNRE) is the focal point of the CBD and IPBES. UNEP-WCMC undertook a video conference with country partners including Thailand, from March 2020 – June 2020, to encourage the exchange of knowledge of the National Ecosystem Assessments Initiative between country partners. In Thailand, this was followed up with an inception meeting organized by ONEP, in February 2021, with key organizations such as the Department of Marine and Coastal Resources (DMCR), the Department of National Parks, Wildlife and Plant Conservation (DNP), Chula Unisearch, and UNEP-WCMC to select the appropriate ecosystem and implementing agency for the ecosystem assessment. This resulted in coastal and marine ecosystems being selected for further analysis and Chula Unisearch being selected as the main implementing agency. A Project Steering Committee and management team were appointed, and a project action plan was developed. These organizational arrangements and action plan are discussed in more detail in the final chapter of this report. This scoping report is the first formal output of the NEA Team and outlines the background for the NEA in Thailand and the anticipated approach and action plan. The scoping report is set out to provide a brief national background, identify key policy questions, data sources and brief narrative of what the national ecosystem assessment intends to cover during the expert evaluation stage.

Objectives

This scoping report in the scoping stage aims to:

- Build awareness and capacity at the national level of the critical importance of biodiversity conservation.
- Strengthen the science-policy interface on biodiversity, ecosystem functions and ecosystem services at the national level.
- Outline how ecosystem assessments and related values can be undertaken in Thailand and support the uptake of assessment findings into national decision-making.

Chapter 2. Scope and Geographical Boundaries

This scoping report will cover the state and trends of biodiversity and ecosystem services (BES) across the country, as well as the factors and threats that affect BES and the impact on human security such as economic, food, health, environment, community, individual and politics, as well as the responses to threats to BES. Although the assessment will highlight marine ecosystems, the assessment data will be based, in line with IPBES guidelines on the production of assessments, on existing data both statistical and spatial data in electronic databases and reports from government agencies, scientific literature, and other published information, including data from fieldwork. The findings of the assessment will be disseminated to the wider public and support policy uptake.

The report also includes an assessment of the state of BES in coastal wetlands ecosystems, which serve as a link between the inland and marine ecosystems. Trans-boundary issues such as marine debris and offshore fisheries will also be considered, as well as climate change, the role of youth in BES, gender balance, economic values of ethnic and local communities (see Box 1), utilization and business in coastal and marine ecosystem as well as the evaluation of the effectiveness and risks of BES conservation and sustainable management measures.

Box 1. Remarks on the terms 'Indigenous and local knowledge' (ILK) and 'Indigenous Peoples' in Thailand NEA report

Referring to the Constitution of the Kingdom of Thailand, 2017, in Section 43 (2): "A person and a community shall have the right to: manage, maintain and utilize natural resources, environment and biodiversity in a balanced and sustainable manner, in accordance with the procedures as provided by law"; and Section 70: "The State should promote and provide protection for different ethnic groups to have the right to live in the society according to the traditional culture, custom, and ways of life on a voluntary basis, peacefully and without interference, insofar as it is not contrary to public order or good morals or does not endanger the security of the State, health or sanitation". The Constitution of the Kingdom of Thailand contains no explicit reference to Indigenous Peoples, nor does it acknowledge or endorse any community as Indigenous within Thailand. However, Thailand supports the inclusion of Indigenous Peoples and local communities in environmental protection and conservation efforts, as Thailand has adopted the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) in 2007, which is the most comprehensive international instrument on the rights of Indigenous Peoples.

Based on this, the Thailand's National Ecosystem Assessment (NEA) process, encompassing this scoping report, as well as the future assessment report and summary for policy makers, will consistently use the term "ethnic community" meaning a group of people that have collective identity and shared culture, language, way of life, wisdom, and beliefs. In the case of coastal communities, the distinctive ethnic community is "Chao Lay" (widely known as sea nomads or sea gypsies) with the three subgroups of Moken, Moklen and Urak Lawoi. In the assessment process and documentation, small-scale local fishing communities that do not share descent/ethnicity with the Chao Lay are called "local communities". As such, "Indigenous Peoples" may still be used in the Thailand NEA documents when the term refers to the general concepts, cases from other countries, or citations from the original sources/documents.

However, there are some data availability challenges in preparing Thailand's marine ecosystem assessment. Thailand has 24 coastal provinces, including Bangkok, but the definition of the coastal boundary differs from area to area due to geographical characteristics. Most of the statistical data used in the assessment will cover only 23 coastal provinces excluding Bangkok, because the capital has only 7.11 kilometers of coastline (DMCR, 2023) (there are three sub-districts near the coast). To avoid overestimation, most of the data used thus will cover 23 coastal provinces, excluding Bangkok. However, certain environmental and ecosystem data will cover 24 coastal provinces including Bangkok (Figure 1) due to biodiversity and ecosystem service effects of climate change. Furthermore, Phattalung province, while lacking a coastline, is considered a coastal province because it is located on the shoreline of Thale Noi Lake, the northern part of the Songkhla Lake Basin, and is influenced by the lake system that connects to the sea and has important marine resources.

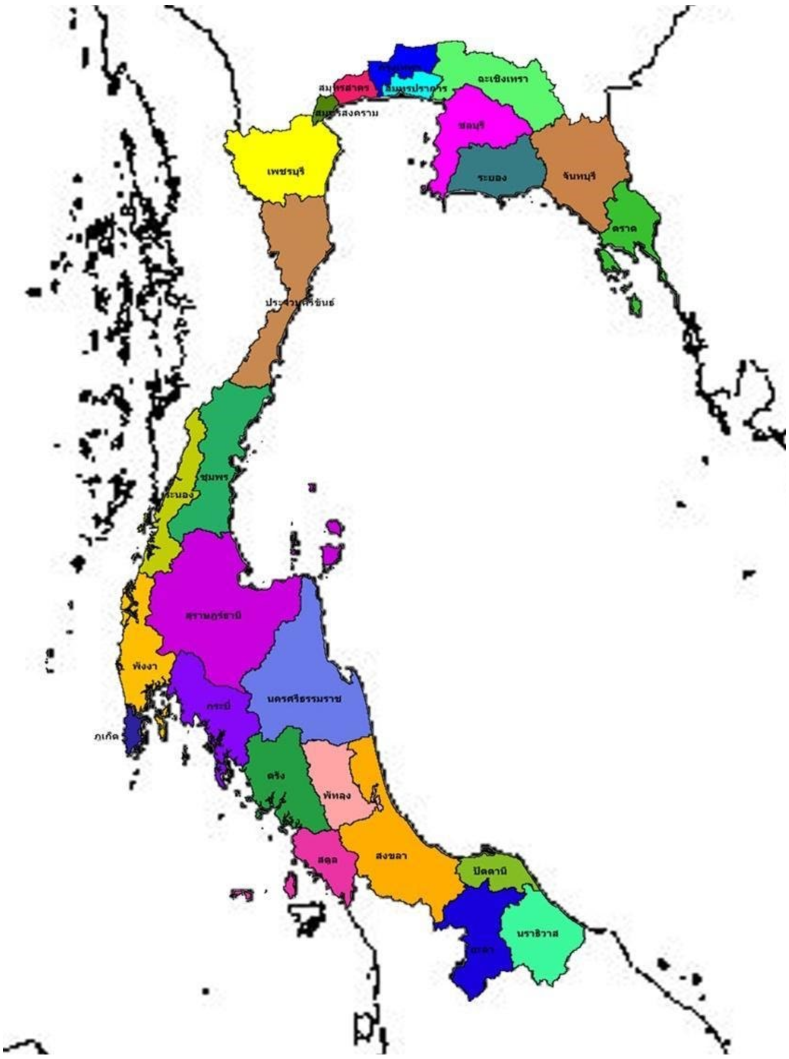


Figure 1: The boundary of 24 coastal provinces
(Source: MKH, 2022)

2.1 Key policy questions

Several policy questions were raised in the kick-off meeting in February 2022 and the NEA meeting at the 7th Marine Science Conference in September 2022. These questions are listed below.

Thematic key policy questions:

- How do marine ecosystems and their ecosystem services contribute to the national economy and human well-being in Thailand?
- What are the investment gaps and how can the private sector engage meaningfully in supporting Thailand's NEA and marine conservation, sustainable use, and restoration in general?
- How can Indigenous and local knowledge (ILK) contribute to the understanding of status and trends of coastal and marine biodiversity and ecosystem services and be strengthened to contribute to the sustainable management of ecosystems and biodiversity?
- What are the best institutional arrangements and governance systems to support the conservation of marine biodiversity and ecosystem services?
- How can the findings/recommendations of the national ecosystem assessment be integrated into national policies and transformed into scenario planning?

Chapter 3. National Background

This chapter will describe the location and geography of Thailand and explain why Thailand is a biodiversity hotspot. The assessment is based largely on secondary data from government agencies.

3.1 Location & geography

Thailand is located between the Indo-Chinese peninsula and the Malay Archipelago, between latitudes 5.610 N and 20.470 N and longitudes 97.350 E and 105.640 E. Thailand's neighbors are Myanmar to the west, Lao PDR and Cambodia to the east, and Malaysia to the south. There are 15 mountain ranges spread throughout the nation, making up a variety of ecosystem landscapes and habitats. The Mekong River, Gulf of Thailand, and Andaman Sea, as well as the watersheds and major river basins that are related to these water bodies, serve as a nexus for the dispersion of plant and animal species, from China and the Himalayas, tropical species from Indochina, and other species from other parts of Asia (CBD, 2024).

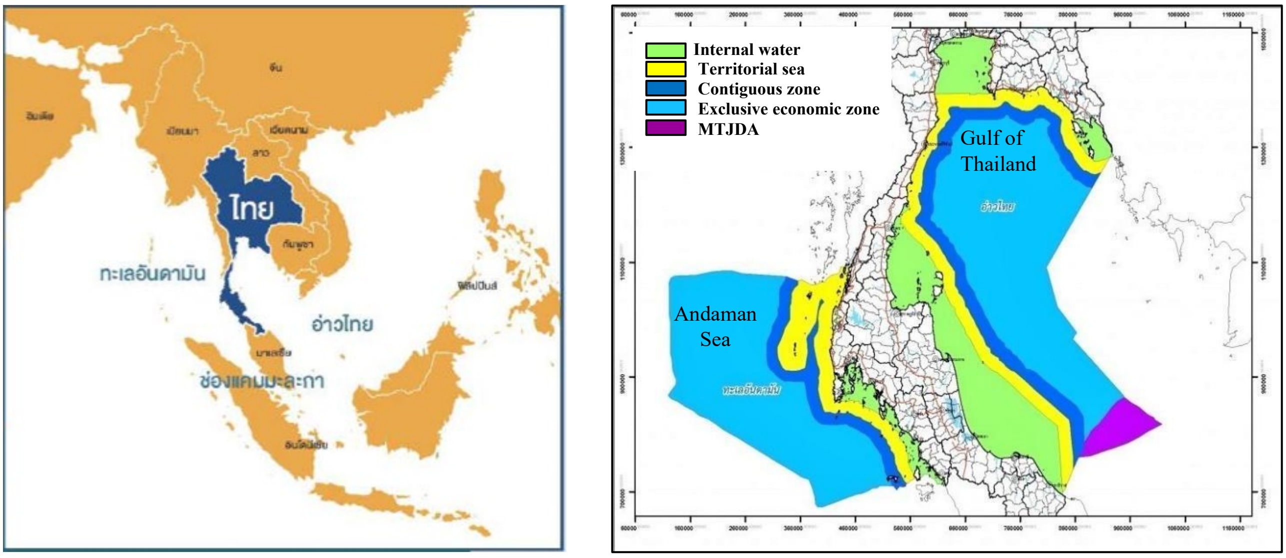


Figure 2: Location and maritime zone of Thailand
(Source: SAKM, 2019)

Thailand has two coastlines that extend for 3,148 km across 23 provinces. This coastal zone includes the Gulf of Thailand (GoT) in the eastern part of the country, the innermost part of the western Pacific Ocean, and on the western part of the country is the Andaman Sea, the easternmost part of the Bay of Bengal of the Indian Ocean. Thailand is a coastal state with a maritime zone covering 323,488.32 km^2. Thailand's maritime zone covers more than two-thirds of its 513,000 km^2 continental area and is divided into four zones: internal water, territorial water, contiguous zone, and exclusive economic zone (EEZ) (Figure 2).

Thailand has a high biodiversity due to its complex geography, ranking 20th as the most biodiverse country (Matthew, 2022). According to Thailand's sixth national report of the CBD (2019), Thailand's ecosystems are classified into seven ecosystems, with agriculture and forest ecosystems accounting for approximately 55.73% and 31.68% of the overall country area, respectively (2018 data). The remainder include maritime and coastal ecosystems, island ecosystems, inland water ecosystems, dry and semi-humid ecosystems, and mountain ecosystems.

Species diversity has also been reported (ONEP, 2020), with about 12,050 plant species in Thailand, of which 10,531 species have been biologically classified. Some 1,185 plant species have been assessed for their status with 1,002 species found to be under threat. There are 5,001 vertebrate species reported, an increase of 270 species identified since 2017, with 694 threatened species divided into 345 mammals (126 threatened), 1,071 birds (191 threatened), 461 reptiles (52 threatened), 184 amphibians (18 threatened) and 2,940 fish (301 threatened).

Over 6,928 invertebrate species have been classified in Thailand, including 3,277 Arthropoda species; 2,535 Mollusca species; 458 jellyfish and coral species; 381 Echinodermata species; 227 Annelida species; 49 Porifera species; and 1 Hemichordate species. Three groups have been assessed for status and found that 107 coral species in the jellyfish and coral group, 14 crustaceans in the Arthropoda group, and 183 Mollusca species are under threat. Moreover, researchers estimated that there are over 200,000 species of microorganisms, but only one in ten were utilized for research and study purposes (ONEP, 2020).

Human activity poses significant threats to biodiversity and ecosystems in the country, including land use change, habitat destruction, agricultural chemicals, ineffective debris/waste management, invasive alien species, wildlife trade, overexploitation, and pollution. Natural hazards such as disasters and climate change are also drivers of loss and degradation.

Chapter 4. Methodological Approach

The Thailand NEA, based on IPBES conceptual framework and methodologies, will adopt the methodological approach used by the Asia-Pacific Regional Assessment (2018) and tailor it to the Thailand context as follows:

(i) The use of the IPBES Conceptual Framework (see **Annex 1**) to highlight how biodiversity and ecosystem services contribute to the economy, livelihoods, food security and good quality of life for human beings through the flow of nature's contributions to people (NCP) which is closely related to ecosystem services.

(ii) Use of the seven guiding principles.

(iii) Determination of the units of analysis and system to be followed. Selecting appropriate units will facilitate comparisons with findings in other Asia-Pacific countries and in the IPBES Asia Pacific Regional Assessment.

(iv) Data collection and interpretation. The NEA will use both secondary and primary data sources where appropriate and a multiple evidence base approach. Primary data will be collected from areas where secondary data is unavailable. Appropriate secondary data, information and evidence will be gathered/compiled from publications i.e., published scientific and grey literature, as well as appropriate ILK sources.

(v) Secondary data will be obtained from the analysis of statistics and interpreted through various analytical approaches such as ecosystem service mapping, participatory discourse analysis, and multi-criteria analysis.

(VI) Multidimensional Biodiversity Index (MBI) (Harfoot et al., 2020) using MBI concept may be applied in target areas where appropriate.

Target Areas

Target areas for more detailed analysis will be selected in the Gulf of Thailand and the Andaman Sea. The criteria for choosing target areas include:

a) Existing data in the area such as state of marine resources, state of human activity, economic, and demographic data
b) Existence of multiple activities that may conflict with biodiversity.
c) Existence of social capital related to culture and ethnic and local communities.
d) Existence of important resources and iconic species.
e) Understanding the factors that drive activity in the area.
f) Important area in terms of environmental, social and economic values.
g) Existence of a related project in the area.

The proposed target areas:

- Phuket province is a representative of well-developed coastal province with mass-tourism and potential development of private Marine Protected Areas (MPAs) or Other Effective Conservation Measures (OECMs) with private sector, and local and ethnic communities.
- Trad province is a representative of lesser-developed coastal province with stronghold of small-scale fisheries, coastal cetacean population and proposed MPAs.

- Ko Losin (Losin island) is a representative of remote offshore MPA under DMCR that is famous for dive tourism in the Gulf of Thailand.

Chapter 5. Marine Biodiversity and ecosystem services assessment in Thailand

5.1 Overview

Marine ecosystems are important environmental systems that play a vital role in regulating the Earth's temperature. They are also critical resources that drive economies, cultures, and societies. Increasing demands from population growth and consumerism are placing these ecosystems under great stress. Global climate change is just one such stress and has helped enhance international co-operation among nations on several environmental fronts. For example, the Kunming-Montreal Global Biodiversity Framework aims to raise awareness among nations of the urgent need to establish suitable policies to mitigate the drastic loss of biodiversity projected for 2030. One aspect of this is to gain a greater understanding of, and promote, the sustainable use of coastal and marine environments, the so-called "blue economy" (ASEAN Leaders' Declaration on the Blue Economy, 2021).

Thailand has undertaken several projects to evaluate marine biodiversity and the country's environmental services. An inception meeting was convened in February 2021 by the Ministry of Natural Resources and Environment, and a resolution was passed to assess the marine ecosystems due to their vital importance and their connections to various sectors, both economically and socially. The resource base of marine ecosystems holds significant potential for the country's economic and societal development. However, there is a lack of knowledge and understanding about biodiversity and environmental services, and information remains scattered and insufficiently comprehensive. This report summarises what is known regarding coastal ecosystems and identifies information deficiencies.

In Thailand marine ecosystems are classified into 6 sub-ecosystems (ONEP, 2020):

1. Beach (sandy beaches, rocky beaches, pebble beaches, coastal forests)
2. Coastal Lagoon
3. Mangrove
4. Coral Reef
5. Seagrass
6. Estuarine

In addition, there are submerged areas and underwater forests that are considered part of the freshwater ecosystem and serve as a connection between terrestrial and marine ecosystems. Together these ecosystems include 273 species of coral, 13 species of seagrass, 5 species of turtles, 1 species of dugong, and 27 species of whales and dolphins. There are 11,900 species of invertebrates and 2,100 species of marine fish (ONEP, 2020). The unique topography of Thailand, with its shallower waters and ample sunlight penetration, allows for higher biodiversity compared to many other regions.

The blue economy, based on these ecosystems and constituent species, had an assessed value of 7.5 trillion Baht in 2007, and 24 trillion Baht in 2014 (NSC, 2015). These evaluations encompass activities such as fishing, transportation, and tourism and, of course, there are many ecological, cultural, aesthetic, social and spiritual values which cannot be assessed in monetary terms.

In the past, various agencies in Thailand have managed natural resources and utilization activities separately, resulting in unclear control and oversight. The 20-Year National Strategy (2017-2036) has set up the National Strategy Committee to develop strategies and indicators. It's noticeable that six groups of key strategies are interconnected with the status and utilization of marine resources, especially in the fifth strategy, which emphasizes the increased marine ecosystem integrity.

The Ocean Health Index (OHI), which aligns with the SDGs, includes ten indicators and has been established in Thailand in 2022. Thailand scores an overall index 66 ranking 99th out of 220 countries (DMCR, 2023). One of these indicators assesses marine biodiversity which had a national score of 84 out of 100 (Ocean Health Index, 2023). Various committees at the ministry level have been established to oversee and ensure the achievement of these indicators. For instance, the National Committee on Conservation and Utilization of Biodiversity focuses on marine conservation policies. Additionally, the National Security Council oversees policies related to marine resource conservation.

However, decision-makers have not fully recognized the importance of biodiversity as they should. Many initiatives are broad and lack specific details, leading to difficulties in practical application and dissemination to operational units. A sustainable management mechanism for marine ecosystems also needs to enhance ILK and integrate it with scientific knowledge. This will facilitate practical implementation, along with using economic tools to incentivize decision-makers.

5.2 Status, Trends and Future Dynamic of Marine Biodiversity and Ecosystems Services Underpinning Nature's Benefits to People

The NEA will provide the status, trends and future dynamic of marine biodiversity and ecosystem services underpinning nature's benefits to people. Existing knowledge will be gathered and systematically reviewed to reflect the past and current status of marine biodiversity and ecosystem services as well as their trends and future dynamics. Integrated ecological assessment of marine biodiversity and ecosystem services will be recommended in terms of methodologies, criteria, classification of marine biodiversity and ecosystem services, indicators as well as monitoring and evaluation framework of marine biodiversity and ecosystem services to build and enhance resilient social-ecological systems and enable nature-based solutions. Knowledge gaps and capacity building needed to understand nature's benefit to people will also be covered.

5.2.1 Past and current status of marine biodiversity and ecosystem services

This section provides a systematic review of past and current status on marine biodiversity and ecosystem services in Thailand, covering genetic, species and ecosystem diversity, and their temporal-spatial variations. Major coastal and marine ecosystems including rocky shores, sandy beaches, beach forests, mudflats, underwater pinnacles, offshore benthic and pelagic ecosystems, etc., are targeted, with special emphasis given to mangrove forests, seagrass beds and coral reefs given their high ecological and social values as well as their areal extent.

Major marine ecosystems are mangroves, seagrass beds and coral reefs.

Mangrove forests

Mangrove forests grow on about 2,780 km^2 in Thailand. Phang Nga province in the Andaman Sea has the largest pristine mangrove forests (461.5 km^2), followed by Satun province (383.3 km^2) (DMCR 2023). Mangrove forests in Thailand have increased in area since 1997 because of the establishment of protected areas and reforestation. There are 96 identified species of mangrove plants; 41 species of them are true-mangroves belonging to 22 genera and 14 families. Dominant species include those in the family of Rhizophoraceae (*Rhizophora spp*, *Ceriops* spp. and, *Bruguieraand* spp.), Sonneratiaceae (*Sonneratia* spp.) and Avicenniaceae (*Avicennia spp*.) (DMCR 2022). Phang-Nga and Trang provinces had the highest species richness of mangroves (28 species), followed by Ranong province (Krabi province (25 species), Ranong province (23 species), Satun province (22 species), Surat Thani province (19 species) (DMCR, 2022; DMRC, 2023). Overall, mangroves are threatened by land-based pollution (particularly solid waste and wastewater), land-use change, fisheries, coastal erosion and development, dredging, etc. (DMCR, 2023).

Mangrove forests play crucial roles in providing blue carbon benefits for climate mitigation. Based on the carbon stock assessment in mangroves of seven provinces (i.e., Chantaburi, Rayong, Nakhon Si Thammarat, Narathiwat, Krabi, Trang, Satun) conducted by the DMCR in 2021, the mean carbon storage of mangroves was 9,868.75 tons of carbon per square kilometer (tons CO_2/km^2). The highest estimated carbon storage of mangroves was found in Trang province (4.2 million tons CO_2), followed by Satun province (3.5 million tons CO_2) and Krabi province (3.2 million tons CO_2) (DMCR, 2022).

Seagrass beds

According to the DMCR (2023), a total of 165.7 km^2 of seagrass beds were found in Thai waters, of which, about 71% was observed in the Andaman Sea. The largest seagrass bed is reported at Ko Libong, Trang province. Most seagrass beds (71%) were poor to fair condition, followed by a healthy condition (29%) (DMCR, 2023). Generally, the distribution of seagrasses is highly dynamic, the cover area and species composition of seagrass beds vary spatially and temporally due to several environmental factors control structure and function of seagrass ecosystems, particularly substrate characteristics, waves, storms, and water quality. There are 13 species of seagrasses in Thai waters, including *Cymodocea rotundata*, *C. serrulata*, *Enhalus acoroides*, *Halophila beccarii*, *H. decipiens*, *H. major*, *H. minor*, *H. ovalis*, *Halodule pinifolia*, *H. uninervis*, *Ruppia maritima*, *Syringodium isoetifolium*, and *Thalassia Hemprichii* (Waycott et al., 2004; Tuntiprapas et al., 2015).

Seagrass beds are degraded by human impacts, especially increasing turbidity and sedimentation in the water due to coastal development, dredging, boating, discharge of untreated wastewater, and sludge from aquaculture (DMCR, 2023). The role of seagrass beds in carbon capture and storage have been discussed, revealing their climate mitigation potential. It was estimated that as much as 134.20 ton CO_2/km2 can be stored in seagrass bed in Thailand; of which, about 97% of the carbon was found in sediment (Stankovic et al., 2021). Besides natural degradation, seagrass beds are degraded by human activities, especially increasing of turbidity and sedimentation in the water due to coastal development, dredging, boating, discharge of untreated wastewater and sludge from aquaculture (DMCR, 2023).

Coral reefs

A total coral reef area of about 238.7 km^2 is found across 17 coastal provinces in the Gulf of Thailand and the Andaman Sea. Surat Thani province has the largest area of coral reefs (57.6 km^2, particularly Ko Samui, Ko Phangann, Ko Kraten and Mu Ko Ang Thong), followed by Phang Nga province (42.7 km^2), and Trat province (28.4 km^2) (DMCR 2023). There are over 280 coral species (71 genera and 18 families) found in Thai waters. *Porites spp*. and *Acropora spp*. are the dominant coral species. The mean genus richness of corals in Thai waters ranged from 0.86 – 2.97. The coral reefs in Trang and Ranong provinces had the highest mean genus richness, accounting for 2.59 and 2.47 respectively (DMCR, 2022). The surveys in 2022 revealed that the majority of the coral reefs were categorized as in healthy condition (53.3%) and in fair condition (22.1%), while 24.6% of them were in a damaged condition (DMCR, 2023). Coral reefs are degraded by coral bleaching events and human impacts, particularly heavy sedimentation, unmanaged tourism, discharging untreated wastewater, improper mooring/anchoring, fishing, and marine debris. Coral bleaching events are mostly found in the hot season when the corals are exposed to elevated seawater temperatures. Bleaching can result in 100% coral mortality on some reefs and, unfortunately, is an increasing source of reef degradation in Thailand resulting from global climate change.

Other important marine ecosystems and species

Peat swamp forests and beach forests are also important marine ecosystems in Thailand. The DMCR reported that in 2022 peat swamp forests covered about 59.4 km^2 in 12 coastal provinces. Songkhla province had the largest area of peat swamp forest (20.5 km^2), followed by Narathiwat province (13.8 km^2) and Pattani (7.2 km^2) (DMCR, 2023). Peat swamp forests are ecologically important and play a major role in carbon sequestration. In 2022, beach forests (such as *Casuarina equisetifolia*, *Terminalia catappa*, *Calophyllum inophyllum*, *Hibiscus tiliaceus*, *Thespesia asiatica*, *Barringtonia asiatica*, *Pandanus odorifer*) covered approximately 75.4 km^2 and were found in 18 coastal provinces in Thailand. Phang Nga province has the largest area of beach forests (37.6 km^2), followed by Krabi (7.1 km^2) and Trang (5.9 km^2) (DMCR, 2023).

Rare and endangered species are of special concern in marine ecosystems. Four groups of marine animals, sea turtles, dugong, dolphins and whales and cartilaginous fishes (whale shark and manta rays) are of particular importance. Five species of sea turtles are found in Thai waters, green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*). Some sandy beaches in Thailand are nesting sites for sea turtles, particularly in Trat, Rayong, Chonburi, Prachuap Khiri Khan, Chumphon, Surat Thani, Nakhon Si Thammarat, Songkhla, Narathiwat, Pattani, Phang Nga, and Ranong provinces. In 2022 (as of July 2022), a total of 604 turtle nests were found, comprising 296 nests of the green turtle, 256 hawksbill turtles, while no leatherback turtle and olive ridley turtle nests were found. The nests of leatherback turtle (1 – 2 nests) and olive ridley turtle (3 – 18 nests) were found in the past three years (2019 – 2021). An increasing number of green and hawksbill turtles nesting are now being recorded (DMCR, 2023). The trends of leatherback and olive ridley turtle nesting were not continuous as no such nesting was found in some years (DMCR, 2023).

Dugongs (*Dugong dugong*) are associated with seagrass beds and found, mostly in the Andaman Sea with small groups in the Gulf of Thailand. Altogether there are about thirteen populations of dugongs, and these are found in Phang Nga, Phuket, Krabi, Trang, and Satun provinces in the Andaman Sea, and Trat, Rayong, Chantaburi, Chonburi, Chumphon, Surat Thani, Nakhon Si Thammarat and Pattani provinces in the Gulf of Thailand. The largest dugong population in Thailand is observed in Trang province. The average number of dugongs decreased between 2007 – 2014. However, an increasing trend is now apparent with a 2022 survey reporting a total of 273 dugongs (DMCR, 2023).

Twenty-seven species of dolphins, porpoises and whales are observed in Thai waters, including nine coastal species and 18 offshore species (Knowledge Management, 2023). Coastal species are Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), finless porpoise (*Neophocoeno phocoenoides*), Indo-Pacific humpback dolphin (*Sousa chinensis*), Irrawaddy dolphin (*Orcaella bfeyirostris*), pantropical spotted dolphin (*Steneno attenuata*), striped dolphin (*Stenello coeruleoolbo*), spinner dolphin (*Stenello longirostris*), Bryde's whale (*Boloenoptero edeni*), Omura's whale (*Boloenoptero omuroi*). Offshore species include blue whale (*Boloenoptero musculus*), fin whale (*Orcoello physolus*), humpback whale, (*Megoptero novoeonglioe*), sperm whale (*Physeter mocrocepholus*), pygmy sperm whale (*Kogio breviceps*), dwarf sperm whale (*Kogio simo*), ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), Cuvier's beaked whale (*Ziphius covirostris*), Blainville's beaked whale (*Mesoplodon densirostris*), killer whale (*Orcinus orco*), short-finned pilot whale (*Globicepholo mocrorhynchus*), false killer whale (*Pseudorco crossidens*), pygmy killer whale (*Fereso ottenuoto*), melon-headed whale (*Peponocephala electro*), rough-toothed dolphin (*Steno bredanensis*), Fraser's dolphin (*Lagenodelphis hosei*), Risso's dolphin (*Grampus griseus*), and long-beaked common dolphin (*Delphinus capensis*). The quantitative surveys conducted by the DMCR focus on the five coastal species, namely Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), finless porpoise (*Neophocoeno phocoenoides*), Indo-Pacific humpback dolphin (*Sousa chinensis*), Irrawaddy dolphin (*Orcaella bfeyirostris*), and Bryde's whale (*Boloenoptero edeni*). The estimated population of those in 2022 was 2310 individuals. Most of them were finless porpoise (30.5%), followed by Irrawaddy dolphin (29.4%), Indo-Pacific humpback dolphin (26.7%), Indo-Pacific bottlenose dolphin (10.8%), and Bryde's whale (2.6%). From 2017 – 2020, the population number of the five coastal species in Thai waters appeared to be increasing and then decreased in 2021 due to some survey limitations during the Covid-19 pandemic (DMCR, 2023).

Two species of cartilaginous fishes are classified as endangered species in Thailand, the whale shark (*Rhincodon typus*) and manta rays (*Manta* spp., *Mobula* spp.). The quantification of their occurrence was conducted via field surveys, reports from divers, tourists, and from the posts on social media. In

2022, about forty whale sharks were found in Thai waters: 21 individuals were found in the Gulf of Thailand and 19 were found in the Andaman Sea (DMCR, 2023). No official data of manta ray population has been documented in Thailand; however, they were found at Ko Ta Chai, Hin Muang Dang, Ko Bon in the Andaman Sea, and Ko Tao and Ko Losin in the Gulf of Thailand (DMCR, 2022; DMCR, 2023).

Human impacts are major threats to rare and endangered species, especially the destruction and degradation of their habitats, food sources, and nesting grounds. The deaths of these species are also due to swallowing plastic waste, entanglement by fishing lines and nets, injuries from physical attack, and illness (DMCR, 2023). During the previous decade, the number of stranded rare and endangered animals increased with an average of 590±220 individuals per year. In 2022 (as of September 2022), stranded sea turtles exhibited the highest proportion (67%) compared with the number of stranded whales and dolphins (30%) and stranded dugongs (18%). The high percentages of dead stranded dugongs, dolphins, and whales were found, ranging from 89 – 93%, while it was lower for stranded sea turtles (54%). The survival rates of live stranded species rescued and treated at the rehabilitation centers were 90%, 50%, and 55% for sea turtles, dolphins and whales, and dugongs, respectively (DMCR, 2023).

5.2.2 Ecological assessment of marine biodiversity and ecosystem services

Different frameworks are available for undertaking ecological assessments as a basis for the NEA. A review of state-of-the-art methodologies (application, assumptions, and limitations) for ecological assessment of marine biodiversity and ecosystem services will be conducted and practical and appropriate methodologies proposed for future implementation under the NEA. Suggested criteria to be taken into account are summarized in Table 1. The outputs from this assessment provide quantitative information for further analysis, particularly the economic valuation of marine ecosystem services.

Table 1**:** Criteria for ecological assessment under NEA project

Sensitive	Is able to provide early warnings and early detection and accurately reflects the condition of the environment and ecosystems.
Representative and transferable	Can be broadly applied at different spatial and temporal scales, across regions and potentially across different habitat types.
Responsive	Is able to establish priorities for management and inform decision-making in a reasonable time.
Ecologically meaningful	Is able to be understood and interpreted and can distinguish between natural and anthropogenic drivers of change, by incorporating sound ecological theory.
Measurable	Should provide the necessary tools and methods for measurement, and its effectiveness should be relatively independent of sample size.
Easy and cost-effective	Is easy to use and interpret and data collection costs should be minimized.
Able to set reference points	Should include the necessary data and methods to set baselines and establish thresholds for conservation purposes.
Able to create awareness	Should aim to improve environmental understanding and awareness to engage effectively with various stakeholders.

(Modified from Smit et al., 2021)

5.2.3 Classification of marine biodiversity (ecosystem structures, function and processes) and ecosystem services

In this section, each key ecosystem will be described in the NEA in terms of its structure, functions, and processes, e.g., production, decomposition, food web dynamics, ecological interactions (inter-and intraspecific), hydrological processes, geological processes, and evolutionary processes. The ecosystem services will be considered in two categories: intermediate and final ecosystem services to illustrate the linkages from ecosystem processes to services. The intermediate services result from ecological components and processes, providing indirect benefits, particularly supporting and regulating services (Lamothe and Sutherland, 2018) and may include primary production, larval and gamete supply, nutrient and water cycling, formation of species' habitat, biological control, natural hazard regulation, waste detoxification, and carbon sequestration. The final ecosystem services are derived from the intermediate services and they can directly deliver welfare benefits to people (IPBES, 2019) and may include the production of fish, algae and seaweed, ornamental materials, genetic resources, water supply, climate regulation, natural hazard protection, water purification, touristic and spiritual places, and seascapes (Table 2). Goods and benefits refer to the outputs from the final ecosystem services that are beneficial to human well-being in terms of both tangible (e.g., natural products, nature balance and regulation, human health) and intangible benefits (i.e., mental and cultural value, appreciation, knowledge). These services will be selected and quantified based on the data availability and practicality, providing inputs for further economic valuation.

Table 2**:** Ecosystem services of marine ecosystems in Thailand

Ecosystem Services	**Provisioning**	**Regulating**	**Supporting**	**Cultural**
Intermediate Services		• Biological control • Natural hazard regulation • Waste breakdown and detoxification • Carbon sequestration	• Primary production • Larval and gamete supply • Nutrient cycling • Water cycling • Formation of: species-habitat; physical barriers; seascape	
Final Ecosystem Services	• Fish and shellfish • Algae and seaweed • Ornamental materials • Genetic resources • Water supply	• Climate regulation • Natural hazard protection • Clean water and sedimentation control		• Seascapes and landscapes

Ecosystem Services	**Provisioning**	**Regulating**	**Supporting**	**Cultural**
Goods/Benefits	• Food (wild, farmed) • Fish feed (wild, farmed, bait) • Fertilizer and biofuels • Ornaments and aquaria • Medicines and blue • Biotechnology	• Healthy climate • Prevention of coastal erosion • Coastal protection • Waste burial/removal/ neutralization		• Tourism, recreation, and nature watching • Spiritual and cultural well-being • Aesthetic benefits • Education, research • Health benefits

(Modified from Turner et al., 2014)

5.2.4 Indicators of marine biodiversity and ecosystem services

Marine ecosystem components, processes and services are complex. This complexity can be understood through the assessment of the status of various key attributes, or indicators. The indicators of marine ecosystem components used to determine the composition of each habitat/species include abundance and diversity of species, characteristics and quality of sea space, seawater, and substratum. Indicators of ecosystem processes include production, decomposition, food web dynamics, ecological interactions, hydrological processes, geological processes, and evolutionary processes. Indicators of ecosystem services measure changes in provisioning, supporting, regulating, and cultural services. A comprehensive list of these different indicators that will help frame the main findings of the final NEA can be found in Appendix
Annex ***2***. It is unrealistic to expect that even a small proportion of such information can be collected, and means must be found to prioritize which indicators should be preferred over others. One important criterion for the NEA is the ease of linking the potential indicator with the provision of ecosystem services. This provides a potential mechanism for not only assessing ecosystem health, but also changing values in ecosystem services. Table 3 provides an example of such a linkage for estuarine ecosystems and will guide thinking regarding indicator selection for the Thailand NEA.

Table 3: The indicators system for estuarine ecosystem health assessment showing links to ecosystem services.

Target layer	**Sub-target layer**	**Criteria layer**	**Indicator layer**
Supporting services	Biodiversity maintenance (BM)	Nekton biodiversity	Mean trophic level (MTL)
		Phytoplankton biodiversity*	Species number
		Zooplankton biodiversity*	Species number
		Benthos biodiversity	Species number Density Biomass
		Indicator species	Abundance/biomass
	Habitat provisioning (HP)	Sea water quality	Dissolved oxygen Inorganic nitrogen Active phosphate
		Aquatic habitat Important and specific habitat	Habitat provisioning (HP) habitat
Provisioning services	Seafood provision (SP)	Seafood products	Fishery yield/ biomass of nekton
Regulating services	Biological control (BC)	Control of ecological disasters	The frequency of ecological disasters
	Water purification (WP)	Physical self-purification	The tidal prism The Bay Openness Index
		Coastal wetland purification	The area of coastal wetland
Cultural services	Tourism and leisure (TL)	Natural shoreline	The length of natural shoreline
		Clean water	The area of clean water
	Scientific research and education (SE)	Landscape naturalness	The area proportion of natural landscape

(Modified from Yu et al., 2022)

5.2.5 Monitoring and evaluation of marine biodiversity and ecosystem services

Monitoring of changes in ecosystem health and related ecosystem services is fundamental to the NEA initiative. Thailand has several monitoring systems already in place, for example for selected coral reef ecosystems, but a more comprehensive and integrated system needs to be developed. The NEA final report will include an assessment of the status and extent of current monitoring systems and suggest what needs to be done to make these more effective, including specific recommendations for certain case studies that can be linked to ecosystem service provision. Table 4 provides an example of appropriate indicators for assessment of the changing health of coral reefs.

Table 4**:** An example of monitoring and evaluation of marine biodiversity and ecosystem services: coral reef ecosystem.

Healthy Coral Reef Indicators	
Coral Reef Extent	Measures area covered by coral reef ecosystems can tell if this is increasing or decreasing
Fleshly Algae Cover and cover of key benthic groups	An increase in the cover of fleshly algae indicates a decline in coral reef health with less diversity of fish and lower productivity
Live Coral Cover	The amount of live coral cover on a reef – an important first look at coral reef health
Live Coral Cover in Restored Coral Reef Areas	A measure providing information on the success of coral reef restoration efforts
Percent Coral Reefs Effectively Protected	That amount of the world's coral reefs that are included within MPAs or Other Effective Conservation Measures (OECMs)
Fish Abundance and Biomass	The number of fish on the reef and the amount of energy available, showing the health and integrity of the system
Index of Coastal Eutrophication	Measures water quality in coastal areas

(modified from CBD, 2022)

5.2.6 Integrated ecosystem assessment to build and enhance resilient social-ecological systems and enable nature-based solutions

The final NEA report will provide insight into how a more interdisciplinary and holistic approach can be used to enhance the resilience of marine ecosystems in Thailand. Such approach not only helps bridge science and policy making but also integrates stakeholder and public participation to build and enhance resilient social-ecological systems and enable nature-based solutions. Table 5 provides some suggestions of how to link resilience assessments of coral reef ecosystems with building local support and informing management decisions. Resilience assessments use both ecological data and the data on anthropogenic impacts, environmental conditions etc. to help identify areas/ecosystems that are most likely to survive climate change and prioritize management actions to support resilience to climate change (McClanahan et al., 2012; Lam et al., 2017). Besides the resilience-based framework, we will also incorporate the nature-based solution (NBS) assessment frameworks (Veerkamp et al., 2021) in support of enhancing climate adaptation and mitigation.

Table 5: Recommendations for using reef resilience assessments to inform management actions.

Building local support (political will; stakeholder engagement; influencing decision-makers)	• Develop resilience assessment priorities in partnership with local stakeholders, ensure sharing of data collected, and explore citizen science opportunities • Include reef managers and decision-makers (when possible) in all stages of the assessment from planning to implementation and identify a local champion to support the implementation • Develop communications regarding the importance of managing for resilience and how assessments can be used to build political will to support the implementation of management actions • Results of resilience assessments can provide a platform to promote reef conservation and greater awareness of the importance of reefs; workshops, campaigns and information displays can be helpful, including how local stakeholders (e.g., tourism operators, students, local government officials) can play a role in reducing damage to and encouraging the protection of resilient areas • Effective collaboration between scientists, ethnic and local communities, and local government officials is needed to integrate scientific data into policy and adaptation measures • Conduct a social assessment of the planning area to identify key stakeholders and assess implementation opportunities and constraints • Map structure and hierarchy of decision-making within the local government to clarify key influencers, appropriate communication channels, and opportunities for influencing decision-makers
Guidance on indicators	• Utilize locally-relevant resilience indicators that have strong links to resistance or recovery based on ILK and that can be assessed using the same methodology for all sites • Important to consider coastal human population in combination with other factors influencing resilience potential, as higher populations around potentially resilient reefs may pose risk of eroding reef resilience • Interpretation of assessment results should consider disturbance regime of reefs (e.g., historical bleaching events, storm impacts) and projections of future exposure • Resilience assessments provide snapshot of status of resilience indicators thus it is important to incorporate long-term trends of the status of indicators to assess the effectiveness of management actions and to inform adaptive management • Remote-sensing data may be used to develop a remotely-sensed resilience index where field data are lacking • Improved access to downscaled and locally-validated coral reef habitat maps from remotely sensed technology are needed, especially in data poor regions • Consider both social and ecological indicators of resilience (e.g., metrics of reef state, disturbance regimes, ecosystem process and function, and changes in population, governance, and technology
Timing of assessment	• Align timing of resilience assessment with management decision-making processes (e.g., rezoning of MPA) • Consider how disturbance events (e.g., hurricanes, mass bleaching events) could provide opportunities for increased awareness of climate impacts on reefs and create public action to support reefs conservation/sustainable use
Standardizing costs and value of cost-benefit analysis	• Standardize how costs are reported in resilience assessments (e.g., including planning costs, boats, gasoline, dive equipment, staff salaries, food and lodging for survey team, and in-kind contributions • Provide decision makers with a cost-benefit analysis of potential management actions in combination with assessment results to help prioritize management actions

(Modified from McLeod et al., 2021)

5.2.7 Knowledge gaps and capacity building needed to understand nature's benefit to people

The NEA will assess the status of current information and make some additions in terms of primary data collection. However, it is equally important to identify and prioritise knowledge gaps and capacity building needs that are the most critical in terms of aiding an improved understanding of the value of ecosystem services in Thailand and the most effective ways to address them. Table 6 provides an example of research priorities on coral reef ecosystems. The NEA will also suggest appropriate targets and pathways to enhance capacity building among different stakeholder groups and sections of society to appreciate the links between healthy ecosystems and healthy societies.

Table 6**:** Research priorities to support the application of resilience-based management: Coral reef ecosystem (modified from McLeod et al., 2019).

Protect a diversity of species, habitats, and functional groups	• For specific reef sites and regions, identify and prioritize which species and functional groups are most important to protect key ecosystem functions and which management actions are most likely to support reef recovery.
Maintain pathways of connectivity	• Guidance for identifying source and sink reefs and high connectivity most likely to support recovery including guidance that can be applied in regions with limited technical and financial capacity. • Evidence is needed to demonstrate if and how social connectivity can support reef health and resilience.
Reduce reef stressors	• Guidance for identifying which stressors are driving reef decline and recovery at sites and prioritizing which management interventions provide the greatest benefits to supporting reef resilience. • Case studies demonstrating if/when addressing local stressors supports reef resilience, including bleaching resistance and/or recovery.
Implement MPAs to support reef resilience	• Increased evidence for when/where/and under what conditions MPAs support/do not support coral resistance and recovery. • Strengths and limitations of MPAs in maintaining coral reefs and the services that they provide, especially compared to other forms of management (e.g., non-spatial fisheries management).
Manage adaptively to accommodate uncertainty and change	• Guidance for overcoming barriers to implementing adaptive management, such as challenges embracing uncertainty; lack of data on key processes (e.g., recruitment), and perceived threats to existing research programs and management regimes.
Prioritize areas with low environmental risk and high social adaptive capacity	• Given the limitations of climate models (uncertainty, spatial and temporal resolution) how should they be weighted alongside variables of current condition to prioritize areas for protection? • Guidance for when to triage conservation at sites based on projections of climate impacts (i.e., are their climate thresholds that warrant eliminating management/conservation interventions at sites). • Identification of coral taxa with high acclimation/ potential adaptation.
Incorporate social and ecological indicators to assess early warnings, recovery patterns, and regime shifts in conservation planning and monitoring	• Improved and finer scale climate models to prioritize when and where impacts are projected to inform management actions. • Guidance on how changes in social conditions can be incorporated into conservation planning and management. • Improved understanding of social and ecological resilience indicators for specific reef regions (metrics that assess recruitment and recovery, adaptive capacity), and how interactions among them may alter their importance. • Locally/regionally specific guidance for predicting thresholds when reefs recover or undergo regime shifts (i.e., tipping points that precipitate regime shifts; how such tipping points vary in different environments).

	• Improved guidance on assessing trade-offs between different management strategies in terms of their costs and social, economic, and ecological benefits.
Invest in experimental approaches to support resilience	• Viability of experimental approaches at relevant scales to protect coral reef ecosystems. • Cost-benefit analysis of active interventions to maintain marine communities and their benefits.
Implement strategies to build social and ecological adaptive capacity	• Guidance on priority indicators of social adaptive. • Clarity on metrics and methodologies to assess social adaptive capacity. • Guidance on how to prioritize management actions to protect key ecosystem functions and support adaptive capacity.
Implement strategies to facilitate adaptation and transformation	• Guidance on facilitating adaptation and planning for social and ecological transformations. • Clarity regarding the degree to which RBM addresses problems that have not been amenable to other approaches.

5.3 Direct and indirect pressures, impacts and response on coastal and marine biodiversity and ecosystem services

Drivers determine the direction of the patterns of activities that affect the increase and decrease of local pressures. These include important policies and strategies of the country's economic, social and cultural development directions including the Sustainable Development Goals (SDGs), Blue Economy, Circular Economy and BCG Economy, Ocean Health Index (OHI), Marine Mammal Protection Importation Law (MMPA), the Convention and International Maritime Law, as well as global and national situations affecting marine resources and the environment such as climate change and the epidemic of coronavirus disease 2019 (Covid-19), etc. The following section will describe the main human activities and present threats and responses.

5.3.1 Pressures and threats

Pressures are human exploitation activities which are based on natural resources and marine environments including various by-products from human activities, whether intentional or unintentional such as building a dwelling coastal development, agriculture, industry, coast, tourism transportation and maritime commerce, fisheries, and exploitation of living and non-living resources, etc. Increasing pressures could lead to the deterioration of marine resource health if not managed well.

Threats are activities or causes that affect the status of natural resources and the well-being of human populations which can be divided into two categories:

(i) Direct threats include:

- **Fisheries** such as the rise of fishing vessels and overfishing, the catching of illegal or destructive fishing gear, illegal fishing in protected areas, coastal aquaculture. etc.
- **Tourism** causing impacts on marine resources such as waste and effluent from homes, restaurants and other services, maritime impacts, reef anchorages, solid waste and increased marine debris, increasing numbers of tourists, including problems arising from the construction of infrastructure to support the expansion of tourism.
- **Shipping** and commerce are coastal utilization activities leading to maritime, coastal port construction, community-wide ongoing activities and land transportation that is important to the development of the country and is an activity that directly and indirectly affects marine resources such

as problems from port infrastructure, or expansion of port areas, problems with coastal waste washed into the sea, oil and chemical spills from cargo ship collisions or shipwrecks, and problems with the spread of alien species that are attached to ballast waters and deteriorate marine ecosystems.

- **Changes in coastal land use and other uses in coastal areas**, including the development of residential areas that affect marine resources such as wastewater and waste discharges, and invade the mangrove forest area for development.

- **Coastal industries** have resulted in land use changes and increases in coastal communities. In addition, the establishment of coastal industrial estates is a factor that leads to pressures on marine resources. This can result in the degradation of marine resources such as smuggling untreated wastewater directly into water sources, chemical spills, effluents and various pollutants that flow into water bodies and flow into the sea. This affects water quality and coastal life. The expansion of the factory area in some areas may be invaded to mangrove forest areas. As a result, the mangrove forest area was destroyed.

(ii) Indirect threats include:

- Natural hazards These include waves, winds and monsoons, high and low tides, currents, and the amount of freshwater flowing into the sea. They affect the health and integrity of coral reefs, seagrass, mangrove forests, seawater quality, and coastal erosion as well as threats from animals such as crown-of-thorns starfishes, sea urchins, and other exotic marine species.

- **Climate change** includes both natural and human-caused changes in global temperature, such as the burning of fossil fuels, deforestation, and industrial grazing that releases carbon dioxide and other greenhouse gases to the earth's atmosphere. This results in rising temperatures and sea levels, which affect marine resources as well as the well-being of the people.

5.3.2 Impacts on human well-being

It is the result of various human and natural activities that cause changes to marine resources such as the degradation of coral reefs, seagrass, mangrove forests, sea quality, coastal erosion, fertility of marine life, biodiversity, food chains, and loss of coastal nursery areas can affect seafood security, as well as the impact on the economy, society and quality of life of communities and countries. It is in the form of 7 dimensions of human security including 1) Food security, such as food shortages and contaminated food, etc. 2) Economic security, such as a decrease in income, 3) Health security, such as illness 4) Environmental security, such as a decrease in the diversity of organisms 5) Personal security 6) Community security, such as resource conflict, and 7) Political stability, such as changes in policies and plans (Department of Marine and Coastal Resources, 2017).

5.3.3 Response to changes in coastal and marine biodiversity and ecosystem services

It is an action taken by the government, the public, the private sector and the organization on the impact of the status of marine resources, in terms of education, research, conservation, restoration and utilization and improvements in policies and strategies to reduce the impacts of the drivers and pressures on the state of marine resources, and coastal erosion. Responses can be divided into resources management, environmental management plans and laws, promoting participation, protection, and suppression, etc.

5.4 Biodiversity and ecosystem services: socio-economic development and human well-being

This section aims to provide an overview of the linkages of ecosystem services, socio-economic development and human well-being. In particular, this section will set the theme for addressing the fundamental problems of coastal and marine resource use and management which will be explored in the Technical Report. Some of the key questions include: What is the cost-benefit comparison of a business-as-usual scenario? What is the cost-benefit comparison of an alternative scenario that means more investment in the restoration of coastal and marine ecosystems? What are the investment gaps? What financial instruments can be prioritized to fill in the investment gaps?

5.4.1 The concept of economic value of biodiversity and ecosystem services in the age of the Anthropocene

The fundamental message which is the foundation of this section highlights that nature's services are of utmost value but seldom recognized and protected by decision-makers. Many of the services are fundamental to human life support on this planet. Examples include the services that mangroves provide in sequestering carbon and protecting coastlines and services of ocean phytoplankton that produce half of the oxygen we breathe. We therefore need to factor in nature's real worth because when we ignore nature's true value, it is not only nature that loses, we also lose. The fundamental principle is that we need to *"sustain that which sustain us"*. We are now in the Anthropocene Epoch which by definition is the most recent period in Earth's history when human activities are having a major impact on the Earth's climate and ecosystems[1]. But humans also have the power to reverse these damages by going through three fundamental steps. The first step is to assess the services that nature provides. Based on this understanding we then move on to the second stage which is to calculate the economic benefits of those services. Beyond understanding and knowing what the economic benefits of those services are, finally, we need to create and implement plans to protect those services based on their true values.

Recognizing that understanding the value of nature may not necessarily involve monetizing its contribution to human welfare but from the framework of an economic analysis, the values that nature provides can be broadly classified into two categories, use value and non-use values. Combined, nature's total worth to human beings becomes the total economic value (TEV). The use value can be further classified into i) direct use and ii) indirect use values. The most commonly recognized value, the use –value, consists of those consumptive and extractive by nature and those that are non-consumptive and non-extractive. Consumptive use value refers to the benefits that human beings obtain from extracting resources and utilizing them for consumption or as material inputs for the production of goods and services that are consumed. The very act of extraction as the term implies means that whatever is extracted is no longer available in its habitat. Less damaging to the natural resources base is the non-consumptive direct use value, which refers to ways in which utility can be generated merely by being able to observe or be close to nature such as nature-based recreational

[1] Video can be viewed through link: https://youtu.be/fvgG-pxlobk?si=0Coz3JyW0_2kMpO9

activities. Less understood is the indirect use value referring to the multiple life supporting services such as water provision, carbon sequestration, coastal protection, production of oxygen, habitat-production linkages, etc. Most abstract is the non-use value which consist of existence value referring to the value humans attach to a particular resource that is not related to any perceived current or future benefits but is merely determined to the desire to know that the natural resources continue to 'exist'. Similarly, for the other type of non-use value, the 'bequest value', person benefit is not in the equation but what creates this value is the desire to know that the natural resources continue to 'exist' for the benefit of future generations.

Specific to coastal and marine ecosystems, Contreras del Valle and Starnfeld (2016) in the Guide to the Economic Valuation of Marine Ecosystem Services listed the types of services, namely provisioning, regulating, cultural, and supporting services deriving from the 4 major sub-ecosystems. The different types of services in Figure 3 corresponds to the types of economic values mentioned above, Provisioning services for example is the direct consumptive use values whereas the cultural services can be monetized as part of the consumptive use values. Better understanding of the regulating services and supporting services can be said to be prerequisites to estimating the indirect use values. It is not always the case, however, that TEV must be estimated. What values are estimated will depend on the ways humans benefit from the stock or the flows of ecosystem services. To a great extent, it will also depend on the potential uses of the estimated values as well as the availability of the scientific knowledge on the biophysical processes of the ecosystem on which solid economic valuation work relies. Within this scoping report, some of the use values of coastal and marine resources have already been presented in section 5.2.

ECOSYSTEM	PROVISIONING ES	REGULATING ES	CULTURAL ES	SUPPORTING ES
Coastal				
Mangrove forests	Commercial fish species, medicinal products, honey, forest products	Water filtration, climate regulation, flood control, water retention, carbon sequestration	Recreational, spiritual	Habitat for species (including those of commercial interest), primary production
Seagrass beds	Fertilisers, medicinal products	Erosion control, nutrient retention, coastal protection, water purification	Recreational	Habitat for species (including those of commercial interest), production of oxygen
Coral reefs	Commercial fish species, raw materials, medicinal products	Coastal protection, nutrient cycling	Recreational	Habitat and maintenance of species (including those of commercial interest)
Dunes	Raw materials, water retention and purification	Coastal protection, erosion control, prevention of saltwater intrusion	Recreational, spiritual	Habitat and maintenance of species
Marine				
Deep sea and pelagic zone	Commercial fish species, medicinal products, raw materials	Carbon sequestration and storage, climate regulation, nutrient cycling, water filtration, bioremediation	Recreational	Production of oxygen, habitat and maintenance of species, genetic diversity

Sources: Dunn et al. (2011), Santora et al. (2021) and Armstrong (2012).

Figure 3**:** Coastal and marine ecosystems and the types of ecosystem services

5.4.2 The economic benefits of services provided by coastal and marine ecosystems

A wealth of studies has been undertaken to estimate the economic benefits of services provided by coastal and marine ecosystems. The content of this section of the scoping report will be a review of those studies that will help provide a better understanding of what is already known about the values of the stock and the flow of services of Thailand's coastal and marine resources. This information will be the basis for determining the knowledge gaps to address in the NEA Technical Report.

A. Mangroves

In 2015, the Economy and Environment Program for Southeast Asia (EEPSEA) commissioned a mangrove scoping study for Thailand. Based on the review of documents related to mangroves from various sources in Thailand, altogether 154 studies were identified. The studies were grouped into 7 categories: (i) those that focus on the economic values of mangrove forests, (ii) community participation and social aspects of mangrove forest management, (iii) benefits of reducing the impact of natural disasters studies which are mostly scientific that focus on the ecological importance of mangroves, (iv) biodiversity resources in mangrove forests, (v) changing quality and conditions of the remaining mangroves, (vi) climate change and (vii) policies and plans. **Error! Reference source not found.** shows the distribution of these studies classified by the different categories.

The studies that focus on the analysis of the economic values of mangroves are the ones that combine the use of bio-ecological models with some economic analysis. While valuable, if any of the values estimated by these studies were to be used for the NEA report, additional work will have to be undertaken to standardize the values. As is, the units of analysis vary; some are values per rai per year, some are values per household/year, others are aggregate values.

In 2008, the DMCR commissioned Kasetsart University to undertake a study to assess the value of economic damages to mangrove communities in selected study areas and develop guidelines on how to take such an analysis. (Kasetsart University, 2008) Altogether 11 types of economic losses were estimated: (i) loss of fisheries, (ii) cost to replant mangroves and maintain the saplings, (iii) use-value of timber, (iv) carbon's sequestration function, (v) opportunity cost of land, (vi) coastal protection function, (vii) increase in land mass, (viii) the benefits of mangrove in reducing the impact of natural disaster and (ix) WTP to support mangrove conservation, (x) the cost to rehabilitate deserted shrimp farms and (xi) biodiversity value.

As part of the inputs for the design of a Payment for Ecosystems Services (PES) project in Krabi province, Biodiversity- Based Economy Development Office (BEDO) commissioned a study on the economic values of ecosystem services from mangroves. The economic value was calculated of benefits such as carbon sequestration and storage function, fishery output, coastal erosion protection, tourist value and mangrove wood products.

A number of studies have looked into how property rights systems affect the level of fish harvest in mangroves. For example, Pongkijvorasin's study on the Value of Mangroves to an Off-Shore Fishery in Bandon Bay, Thailand used a dynamic ecological-economic model to examine the impact of mangrove reforestation on fish stock and offshore fisheries using nutrient status and biological productivity. Under open-access conditions, an additional 1 km^2 of mangrove leads to an increase in fishery production, as well as total revenue and cost by almost 8% (equivalent to around 5 million Baht/year or $130,000/year). Under monopoly conditions, an additional 1 km^2 would increase in fishery production by around 5%. The profit increases by 4.36%. Changing regulatory regimes from open-access to monopoly would increase the stock of fish in the area, from 7,226 tons to 10,230 tons having a significant net impact on net revenue. (Pongkijvorasin, 2009)

An earlier study, Aniya (2002), explored the importance of fishery regulation on the valuation of mangroves by using a simple dynamic model to estimate on and off-site values. Tingsabadh and Pongkijvorasini (2004) focus more on modelling the ecological linkage between mangroves, nutrient, and fish productivity in the area under open-access regulation.

The most cited economic valuations are by Barbier which originated from the EEPSEA funded study on 'Economic valuation of mangroves and the roles of local communities in the conservation of natural resources' (Sathirathai, 1998). This was more or less a spring board which preceded other studies and publications by Barbier and colleagues over the years including: Valuing the environment as input: Review of application to mangrove-fishery linkages (Barbier, 2000), Habitat-fishery linkages and mangrove loss in Thailand (Barbier, 2003), Shrimp Farming and Mangrove Loss in Thailand (Barbier and Sathirathai, 2004) Mangrove Conservation vs. Shrimp Farming in Thailand (Corps, 2007).

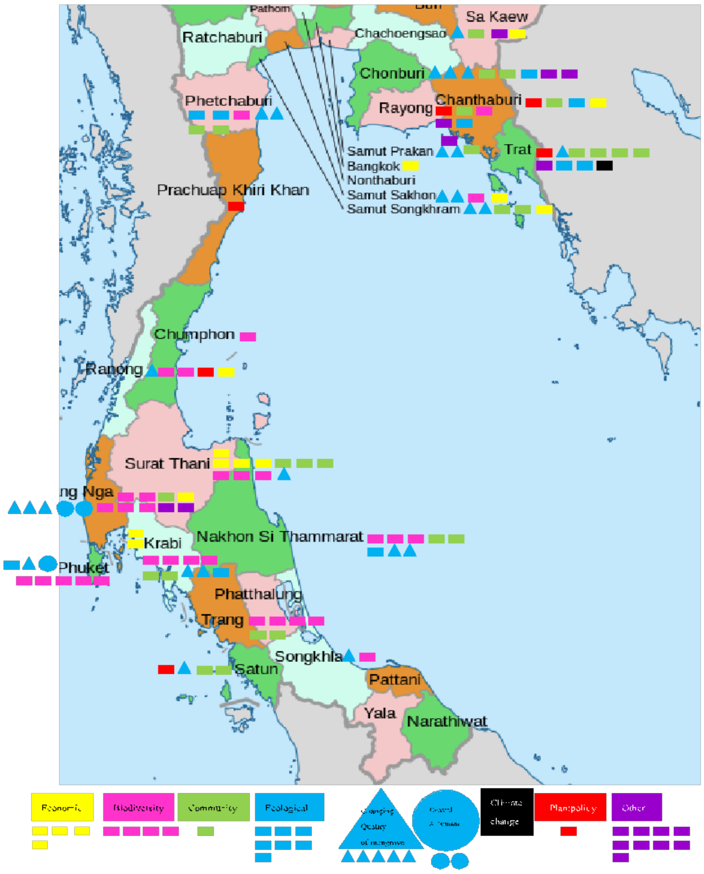


Figure 4**:** Distribution of the different groups of mangrove-related studies
(Source: Nabangchang, 2015)

A 2019 study (Nabangchang and Vincent, 2019) estimated the economic values of ecosystem services provided by mangroves in order to clearly demonstrate the economic losses if mangrove areas are converted to alternative uses as well as the benefits from investments in mangrove conservation. Three types of economic values were estimated, the use value from fisheries, indirect use value for carbon sequestration function and non-use values. The study also analyzed the economic feasibility of investment in mangrove conservation for the potential benefit of generating revenue from blue carbon. The study also looked into how the status of mangroves in certain protected areas such as National Parks, may result in reducing the rate of loss or conversion for alternative uses.

Over 90% of the species caught depended on the mangroves in some part of their life cycle. This finding confirms the benefit of mangroves as spawning, nursery and habitat for marine species and the assumption that the deterioration of mangroves and the reduction of mangrove areas will have direct impact on small-scale fisheries and related downstream economic activities. Net income per year averages at 85,669.7 Baht/household. For fishers who only fish in the mangroves, net income per year averages at 46,493.3 Baht/household. For fishers who only fish in the open seas, net income per year averages at 110,239.4 Baht/household.[2] The non-use values of mangroves were estimated by using Choice Experiment Method. Mean Willingness to Pay (MWTP) for Bangkok was 385 Baht/household. Using differences in income between Bangkok and the rest of the country, the estimated MWTP for the rest of the country was 206 Baht/household. Multiplying these MWTPs with the number of households in Bangkok and in the rest of the country gave a total non-use value of 4,895.76 million Baht. Dividing this number by the current mangrove area of 1,530,000 rai produced a non-use value per rai of mangrove of 3,199.85 Baht.

B. Coral reefs

The economic value of coral reefs is one of the most comprehensively studied areas with studies on direct use values from tourism (Pham Khanh Nam et ala., 2005; van Beukering et al., 2006) and fisheries (Dulvy et al., 1995; Russ and Alcala, 1996; Cesar, 1996; Gustavson, 1998; Ohman and Rajasuriya, 1998; Bene et al., 2010; Cisneros-Montemayor et al., 2016) Indirect use values such as coastal protection (Ruitenbeek et al., 1999; Leeworthy and Wiley, 2000; Hargreaves-Allen, 2004) as well as non-use values (Jacobs, 2004; Herman, Cesar and van Beukering, 2004) have also been studied.

For Thailand, the most recent study undertaken was the 2021 study supported by the Thailand Research Fund. Values estimated included the recreational use value of coral reefs using Koh Tao as the case study area, use values from fisheries and non-use values. The Travel Cost Method (TCM) was used to estimate the use value of reef-based tourism. The consumer surplus is estimated as 6,223 Baht/person/trip. Based on this value and the reported number of 500,000 tourists in 2018, the total use value from tourism can be estimated at 3,115 million Baht/year.

Revenue forgone for reef-related coastal fisheries was estimated using net factor income approach. The data used for the analysis were from interview of altogether 248 small-scale coastal fishers comprising 118 fishers from Koh Phang Ngan and Koh Tao and 130 fishermen from the coastal districts of Satun. Average annual costs were 102,703 Baht per fishers per year for Phang Ngan and slightly lower at 71,572 Baht/ fishermen/year for Satun. Average net revenue for the small-scale fishermen in the two provinces were respectively 181,383 Baht and 145, 995 Baht/fishermen/year respectively.

The non-use value was estimated by using Choice Experiment. The hypothetical goods posed to ask respondent's willingness to pay were i) measures to treat a percentage of wastewater prior to being discharged into the sea, ii) imposing no dive zones for some dive sites which were observed to be more ecologically sensitive and iii) replanting corals in designated sites around the island. A total of 576 respondents were interviewed. For international tourists WTP to move from the status quo to level 1 was 830.6 million Baht. WTP to move from level 1 to level 2 and level 2 to level 3 were respectively 1,661 million Baht and 2,491 million Baht respectively. For the households interviewed in Bangkok, willingness to pay of the two groups of respondents combined to move from the status quo to level 1

[2] Altogether 778 small scale fishermen were interviewed.

was 848 million Baht. WTP to move from level 1 to level 2 and level 2 to level 3 were respectively 1,697 million Baht and 2,545 million Baht respectively.

c. Seagrass

Few studies have been undertaken to analyze the economic value of ecosystem services of seagrass beds in Thailand. One such study is the one commissioned by the DMCR in 2012.The main focus of the study was on the non-use value of the dugongs and given the limited scope of this study, it was not possible to estimate other types of economic values to present a more comprehensive estimation of the Total Economic Value of the seagrass ecosystems. The economic value of only one indirect use value was estimated namely the carbon sequestration and storage functions. The total carbon stored in seagrass beds nationwide is 5.695 million tons, which is estimated from a carbon storage capacity of 48 tons/rai and the total area of seagrass beds in Thailand of 118,665 rai. The volume of carbon stored is converted into the weight of carbon dioxide using the conversion rate of 1 ton of carbon to 3.66 tons of carbon dioxide. Since 1 ton weight carbon dioxide is equivalent to 1 carbon credit, the carbon stored in the seagrass beds is equivalent to 20.85 million carbon credits. Using the average carbon price of 2011 in the Voluntary Carbon Market of 6.2 USD/ton CO_2, the value of Thailand's seagrass beds in terms of carbon storage would be 129.3 million Baht. The carbon storage value of the seagrass beds in Trang province is 6.306 million USD.

In the same study, the estimation of non-use values of seagrass ecosystem was done by using Choice Experiment Method. The non-use value per household for the 4 districts of Bangkok and for Trang was estimated to be 2,022 Baht and 3,879 Baht respectively. Multiplying these values with the number of households in the 4 districts of Trang and Bangkok resulted in a total non-use value of approximately 5,336 million Baht. The economic value of the direct, indirect and non-use value of seagrass ecosystems combined amounted to 5,570,203,567 Baht comprising use value from fisheries (42,131,123 Baht), use the value from tourism, (192,415,397 Baht), indirect use value from carbon sequestration (189,202, 170 Baht) and non-use value (5,335,657,047 Baht).

D. Iconic Marine Species

Among the most studied assets of coastal and marine ecosystems are iconic marine species (Figure 5). Over the years, stated preference studies have been conducted on selected species which can be used as the basis for the formation of the understanding of their economic values. The first of these studies involving Thailand was on the non-use values of marine turtles. The study was conducted in China, the Philippines, Thailand and Vietnam using a Contingent Valuation Method to conduct face-to-face interviews with 3,760 respondents in the capital cities of these countries and Davao in the Philippines (Jin et al., 2010). Subsequent studies on manta rays, whale sharks were funded by the World Wildlife Fund (Nabangchang, 2011). With a direct mandate on protection and conservation of marine species, the DMCR has commissioned three subsequent studies on dugongs (Nabangchang, 2012), Irrawaddy dolphins (Nabangchang, 2009) and Bryde's whales (Nabangchang, 2019). In addition to these studies, an on-going study on the costs and benefits of investments in Marine Protected Areas is using a Contingent Valuation Method to estimate willingness to pay to support investments in establishing three selected MPAs which are also habitats and feeding grounds of iconic marine species. A summary of estimated non-use values is shown in Table 7.

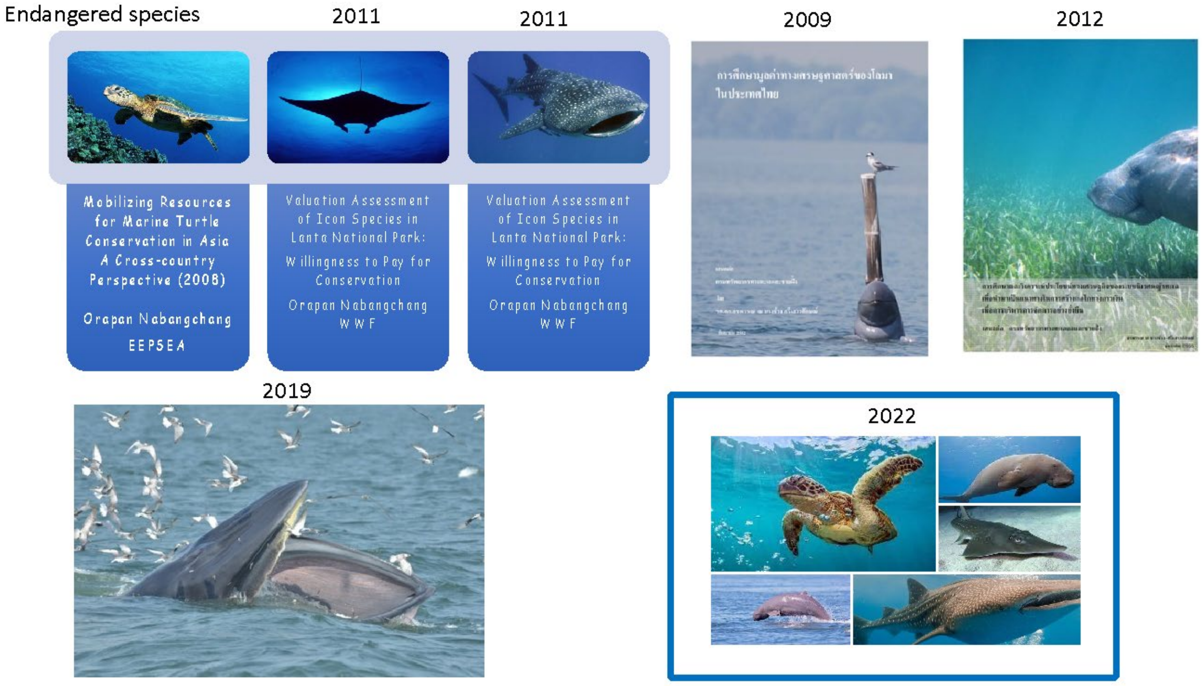


Figure 5: Existing studies on non-use values of marine icon species in Thailand

Table 7**:** Summary of the estimated non-values of iconic marine species in Thailand

	Value estimated	USD/household (hh) (@ 31 Baht/1 USD)
Marine Turtles: Thailand EEPSEA (2008)	Non-use: CVM	1.41 USD/hh for a period of 5 years
Group of Thailand's endangered species: EEPSEA (2008)	Non-use: CVM	Mandatory payment: 20 USD/hh Voluntary contribution: 18 USD/hh
Irrawaddy Dolphins: DMCR (2009)	Non-use: CVM	16 USD/hh
Manta Rays and Whalesharks: WWF (2011)	Non-use: CVM	International tourists Whalesharks: 47 USD/hh Manta Rays: 51 USD/hh Thais: Whalesharks: 11 USD/hh Manta Rays: 10 USD/hh
Seagrass ecosystem and dugongs. DMCR (2012)	Non-use: Choice experiment	Trang province: 127 USD/hh Bangkok: 66 USD/hh

Bryde whales. DMCR (2019)	Recreational value: TCM (471 respondents) Non-use: CVM (661 respondents)	Consumer surplus 111 USD/trip

There are relatively few economic valuation studies of coastal and marine resources in Thailand. There are isolated case studies (Figure 6) but noncomprehensive evaluations. Although there are study sites on both the Gulf of Thailand and the Andaman coasts, the values estimated are not representative of the sub-ecosystems along each of the coastlines and clearly more research is required to fill in this important knowledge gap.

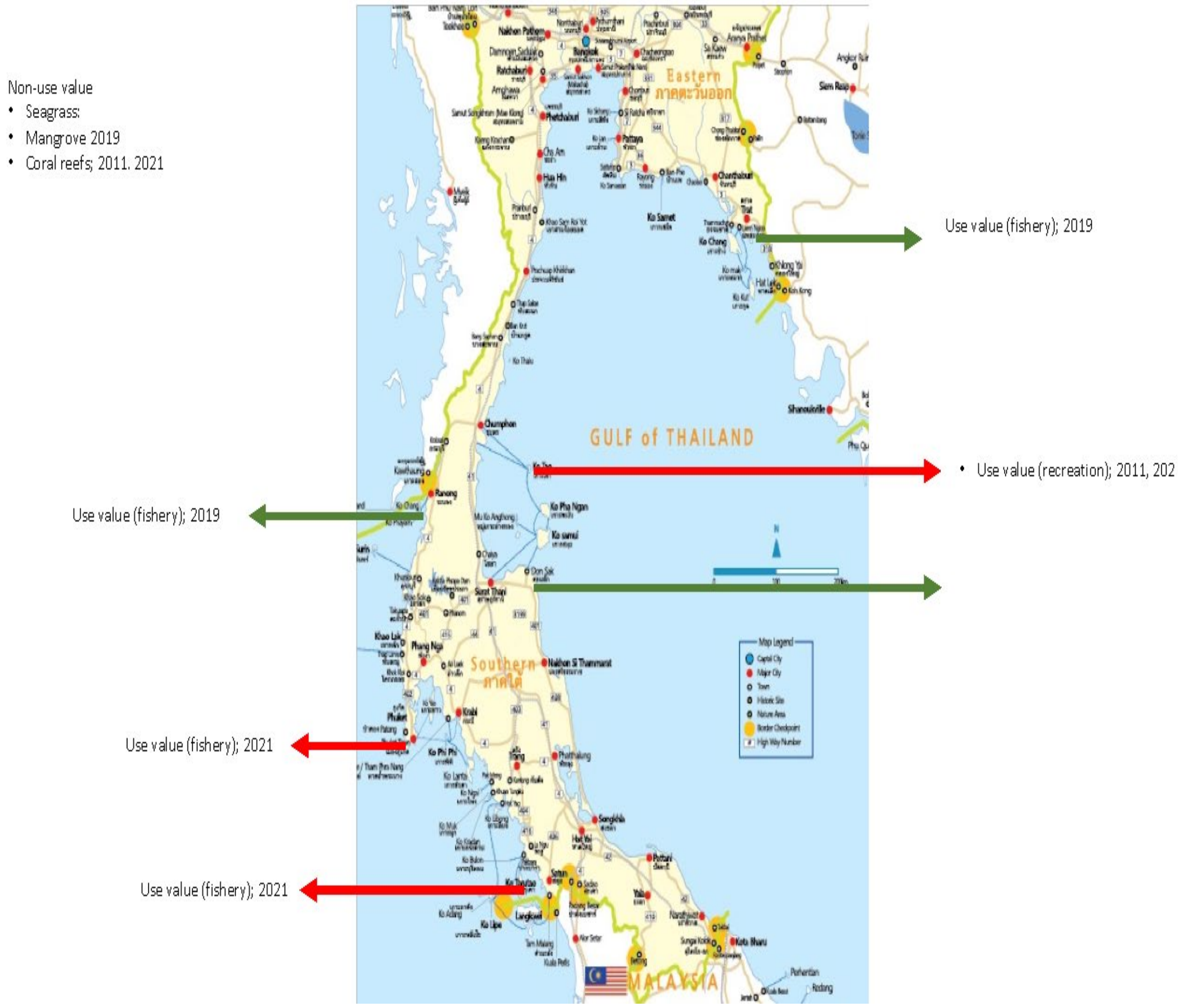


Figure 6: Distribution of economic valuation studies on coastal and marine resources

In an on-going cost-benefit analysis of establishing MPAs, it is expected that more area-specific provisioning services in terms of use values from fisheries of mangroves and coral reefs will be generated (green boxes in Figure 7). However, this still leaves a large knowledge gap for the seagrass ecosystem.

ECOSYSTEM	PROVISIONING ES	REGULATING ES	CULTURAL ES	SUPPORTING ES
Coastal				
Mangrove forests	Commercial fish species, medicinal products, honey, forest products	Water filtration, climate regulation, flood control, water retention, carbon sequestration	Recreational, spiritual	Habitat for species (including those of commercial interest), primary production
Seagrass beds	Fertilisers, medicinal products	Erosion control, nutrient retention, coastal protection, water purification	Recreational	Habitat for species (including those of commercial interest), production of oxygen
Coral reefs	Commercial fish species, raw materials, medicinal products	Coastal protection, nutrient cycling	Recreational	Habitat and maintenance of species (including those of commercial interest)

Missing

Undertaken within the MPA study

Figure 7: Types of economic values that will be estimated within the existing CBA study and remaining knowledge gaps (Modified from Nabangchang, 2015)

Apart from the scarcity of the number of studies, there is also the issue of the validity of the existing studies that can be used to support decision-making. Many of the studies that estimated non-use values are now dated, values have increased, and methodologies have improved. Nonetheless, there is some useful information from these studies such as the detailed information available on mangrove replanting and maintenance costs, and the cost of the different types of physical structures to prevent coastal erosion. At least, these can be used as a reference for lower bound values of the coastal protection function of mangroves.

On the use value of fisheries from mangroves, some of the earlier studies may have methodological issues that might need to be revisited, such as the calculation of use value for fisheries by dividing the output from artisanal fishery with the mangrove area which is then multiplied by market prices. There is also the issue of the statistics on the catch volume of artisanal fisheries from the Department of Fisheries. Unless there is an in-depth and reliable household survey of artisanal fisheries, there is no alternative but to use these statistics as the basis for estimation of use value. Also questionable are the assumptions over both negative and positive externalities of mangroves such as the measurement of the benefits in terms of coastal protection and particularly the contribution to the increase in land mass and the assumption that the revenue generated from coastal fisheries is entirely attributable to the existence of mangrove forests. Some approaches to measuring replacement costs to include as part of the damage costs are also questionable such as the cost to restore former shrimp farms by using the market value of soil to landfill and the cost of land leveling.

The need to exercise caution has also been stressed in the IPBES Regional Assessment report (IPBES, 2018). The general guideline is that extreme caution must be exercised in using these estimated values as references, due to uncertainty over implementation of field surveys and the appropriate units of value.

Given the resource and time constraints, it will not be possible to fill all the knowledge gaps, hence the emphasis on taking a pragmatic approach. This means the need to prioritize what studies can be undertaken, and making decisions about what information can be used as proxy values until Thailand can generate its own body of knowledge.

The NEA for Thailand can capitalize on the wealth of data on the physical parameters on coral reefs, mangroves and seagrass periodically collected by the DMCR which renders it possible to combine the spatial and bio-physical data with social economic data. As suggested by Bateman et al. (2011), once the scoping report is adopted, the first step to undertake in the economic analysis is to brainstorm and reach a consensus of what types of benefits from the ecosystems services to be included as not all benefits are amenable to monetary evaluation. The economic framework which seeks to monetize the different types of services may overlook or have limitations in demonstrating the values of nature from the perspective of ethnic and local communities that depend on them. Referring to the IPBES Regional Assessment report, how people value nature will depend on knowledge systems, cultural background, and the specific environmental context. Monetizing the ecosystem services could be a way to communicate with decision makers but it is not the only way. Other valuation approaches will be needed which can better reflect those values. This will be followed by the work on constructing the future paths of ecosystem services. By the nature of the knowledge required to undertake both stages, the work is 'transdisciplinary' by nature and not something that can be accomplished by the team of environmental economists.

5.4.3 Moving forward from recognizing and calculating values to capturing the values for sustainable use

At present, biodiversity conservation in Thailand relies heavily on legal measures. Without effective control measures, various pieces of legislation have their limitations. Implementing agencies will never have sufficient resources to protect natural resources. There are different approaches to understanding our relationships with natural resources. Cultural and traditional practices can provide motivations to access and utilize natural resources. From an economic perspective however, over-exploitation of marine resources, like all public goods, is due to the failure to recognize that the economic value exceeds the market prices of its tradable parts. Unless there is greater recognition of the non-tradable benefits and other ways to value biodiversity resources, the benefits gained will continue to be underpriced. In the preceding section, we discussed these values and the knowledge gap that remains. Taking off from that, this section will discuss the financing mechanisms for capturing those values, highlighting in particular, the financing mechanisms which involve restoring and conserving nature to ensure the sustainability of the natural capital stock as well as the continued flow of goods and services.

Moving forward from recognizing and calculating values to capturing the values for sustainable uses through effective planning and implementation can support a range of conservation and restoration actions, including NbS. Thailand is not short of plans which at least serve as written commitments. For the coastal and marine sectors, multiple plans exist such as DMCR Plan, Marine Debris Plan, Dugong National Conservation Plan, the plan to establish 33 additional Marine Protected Areas, plans specific to Marine National Parks, etc. Implementation of the plans to reach the expected conservation goals, however, require adequate resources without which plans will only remain piles of wish lists. To quote the Dasgupta Review (Dasgupta, 2021), we need '*large chunks of investment'* to '*depart from the current paradigm that coastal ecosystems is worth more dead than alive*' we need to '*flip*' the economics and work on both sides of the equation, the demand side as well as the supply side. Flipping is necessary because the amount of money going in to destroy coastal ecosystem is 40 times larger than money being invested in conservation. Unless flipping occurs, the gap between what we have and use and what we need will persist and most likely widens due to the increases in the damage that we continue to inflict upon the marine ecosystems.

On the demand side, one possible solution is to create markets for the non-tradable services provided by the coastal and marine ecosystems. A range of financing mechanisms are available, but Thailand needs to be strategic in our choices because not all of them can be readily implemented. All entail costs and benefits, lag time to invest, lag times before results can be discerned, measurable and quantifiable.

Finance Tools for Coral Reefs Conservation: A Guide (Iyer et al*.,* 2018) has categorized the financing mechanisms in terms of ease of implementation and revenue generating potential (Figure 8). Financing mechanisms within the dotted red squares are those that already exist in some diluted forms in Thailand and could potentially be revamped to render greater effectiveness in revenue mobilization. These include i) Donations/philanthropy, ii) Entrance and access fees, iii) Taxes and levies and iv) Conservation Trust Funds. Based on stakeholder consultation under the BIOFIN Thailand project, there has been preliminary agreement that the mechanisms in the dotted blue square are the ones that could be possible financing mechanisms but will need considerable upfront preparation methods (beyond the economic rationale for adopting them). In the following appendix, these mechanisms are discussed in detail, highlighting its current status in Thailand, advantages and potential as well as the risks and challenges in adopting them. Information/knowledge gap of these financial mechanisms are also discussed together with some of the practical next steps that need to be undertaken.

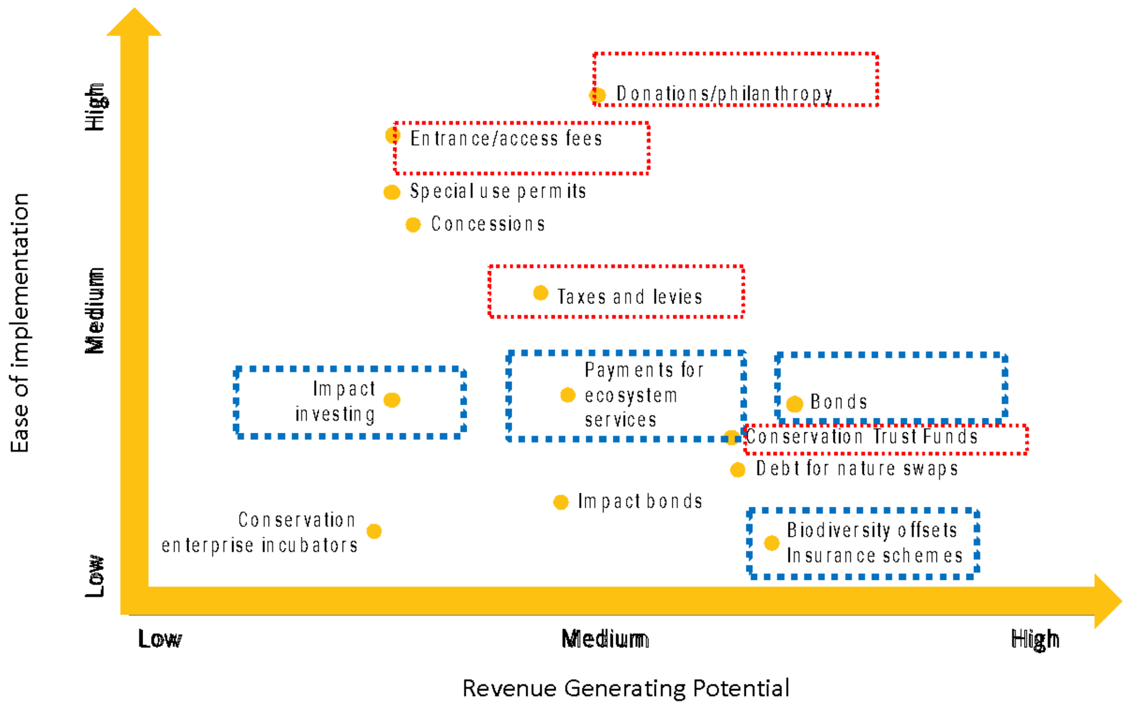


Figure 8: Financing tools for coastal and marine ecosystems. (Modified from Iyer et al., 2018)

Payment for Ecosystem Services

Payment for Ecosystem Services (PES) is a system where the beneficiaries of ecosystem services pay the service providers for the services rendered in looking after, protecting and/or restoring natural resources. Beneficiaries can range from individuals, communities, and business sectors that use natural resources to produce goods and services or even the public sector. In general, the incentives of the beneficiaries originate because of cost savings consideration or assurance of continued supplies of goods or flows of services from the ecosystems they benefit from. All of the coastal and marine ecosystems provide all the four types of services classified by the MDG (namely provisioning, regulating, cultural and supporting) and without PES, beneficiaries may be paying only the tradeable parts of the goods and services. The non-tradable dimensions of services become missing markets and the root cause of market failure and environmental problems. PES can be applied in all cases involving restoring, rehabilitating, and protecting marine ecosystems, specifically mangroves, seagrass, and coral reefs. The presence of iconic marine species such as whale sharks, marine turtles, dolphins, Bryde whales will add to the attraction of those sites and creates the much needed 'face' to conservation which is most likely to increase incentives to contribute to conservation measures.

There are opportunities for adopting PES as a financial mechanism for management of Thailand's coastal and marine resources. Although the existing legal framework may not explicitly endorse the concept of creating incentives for service providers (particularly ethnic and local communities), there are modalities through which these can be relaxed in specific cases if this would enable the implementation of pilot projects. There is potential to tap and divert some of the corporate social responsibility (CSR) resources to support PES projects[3] and there is potential to tap on the CSR funds and direct these to areas where funding is needed to finance communities as 'service providers'. To widen the scope of private sector involvement, however, there is a need for a formal institutional framework to create tangible incentives for the private sectors to be involved.

In principle, a blue bond is issued to support investment in healthy oceans and blue economies. Investors lend money to bond issuers which could be governments, banks or companies who are obligated to pay interest every year during the lending period which the bond covers plus capital at the date when the bond expires. Issuing bonds is not something new to the Thai government. What is new is that the concept has never been applied to the blue sector. Types of projects typically funded by blue bonds that could potentially be the source of finance for the coastal and marine sector include sustainable fisheries, ecosystems management and restoration, coastal and marine tourism. Blue bonds could potentially be instrumental in mobilizing funds to implement a national scale mangroves, coral reefs, and seagrass restoration effort with clarity that the proceeds from the bonds should be tied to concrete conservation measures that produce measurable and tangible outcomes.

Impact investment

Impact investing is an investment strategy that seeks to generate financial returns while also creating a positive social or environmental impact. Examples of impact investment projects include the Rhino Impact Investment Project where an outcome-based bond worth 150 million USD Wildlife Conservation Bonds have been issued to finance rhino conservation activities in South Africa. Another example is the Blue Impact Fund which is a collaboration between Finance Earth and WWF since 2018 which targets enterprises producing sustainable seafood and aquatic plants to demonstrate that attractive returns can be achieved while delivering ocean resilient and recovery. Despite having numerous national strategies, plans, action plans, similar to other countries worldwide, Thailand faces a significant funding gap to launch nationwide conservation activities. In the case of the Dugong National Conservation Plan for example, there are no special budgets earmarked to implement the plan. Line agencies are requested to contribute as deemed appropriate. Financial mechanisms such as the Impact Investments could be a possible solution for making sure that there are adequate financial resources to implement those ambitious plans. The Dugong National Conservation Plan already spells out the 'what' to do, e.g. creating de facto 'no take zones', improving water quality through nutrient removal, reducing incidences of disease and invasive species, reducing waste and pollution. Converting this into impact investments will necessitate looking into the details of the 'hows', with what resources, the tangible outcomes and how this is linked to the fundamental question of how these outcomes will minimize and reverse risk of extinction.

Performance bonds

Proceeds from performance bonds are essentially money paid as a deposit against possible environmental damages or provisions for sustainable use which may arise in the course of carrying out an economic activity, such as construction, tourism or the extraction of offshore gas or minerals. These

[3] Some of the CSR investors for example, included The Coca-Cola Foundation Thailand, the Petroleum Authority of Thailand (PTT) Public Company, the Electricity Generating Authority of Thailand (EGAT).

are usually refundable on the completion of economic activities, if no damage or non-compliance has been demonstrated to have taken place. There is as yet no experience in issuing performance bonds in Thailand but many large-scale infrastructure and coastal development projects including offshore gas and oil exploration poses risks to the fragile coastal and marine ecosystem. Beyond conducting the EIAs, a mechanism needs to be put in place to ensure that all possible liabilities will be covered. The requirement that investors purchase 'performance bonds' would not only create incentives for compliance to environmental regulations and standards as well as incentives for reducing externalities but would also motivate investors/developers to take the necessary precautionary measures and as far as possible avoid any adverse environmental impacts that are likely to occur. Moreover, the existence of this financial mechanism will ensure that sufficient funds are available to mitigate or remediate the effects of environmental damage.

Biodiversity offsets

Biodiversity offsets are a regulatory instrument for assigning financial liability for environmental damage to developers and have significant potential to generate revenue for marine conservation (Bos et al. 2014; Walsh, 2017).

Many investment projects, more specifically coastal infrastructure investment projects, offshore oil and gas exploration and extraction create damages for which the investors are seldom fully responsible for the cost of damages incurred. This is a financial instrument which will require companies to recognize and take measures to prevent, reduce and mitigate their impacts from a planned development, and where mitigation measures would be inadequate to offset residual impacts. This could be a tool to ensure that such investments will create no net loss and at best in net gain of benefits to society by ensuring that approval of investment projects become contingent on the investors accepting full responsibilities of the damages. As a precautionary step to adopting this mechanism, it is necessary to be aware of the controversies. Some of the counter-arguments see biodiversity as a 'license to pollute', that the option of being able to offset the adverse environmental impact will provide incentives for investors to embark on projects that they would otherwise not contemplate. As Iyer et. al (2018) observed, the decision to adopt this mechanism, for all its promises, will take more time and upfront resources to put in place.

Mitigation banks

A mitigation bank is a wetland that has been restored, established, enhanced, or preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources. The experiences of the United States illustrate a modality of how to use existing command and control measures to create demand for these conservation credits as well as the preparatory works to be undertaken to define and calculate the mitigation credits, developing a cadre of qualified human resources to manage the transactions, laying out the transaction procedures, etc. In the Thai context, all categories of marine protected areas that are under the jurisdiction of the DMCR and DNP could potentially be developed as sources of mitigation credits that are of economic value. On the other hand, protecting existing mangroves and restoring mangroves that are currently in degraded condition will require adequate financial resources, a universal problem of all line agencies. This highlights an issue that will be discussed in the last paragraphs of this section which is the combination of financing mechanisms and the information needed which currently do not exist and the practical next steps.

None of the financial mechanisms discussed can be launched until substantial groundwork has been done to fill in the information gap. Figure 9 lists out the information needed for each although in general, what is essential are site specifics data, economic values of ecosystems and services which is essential for determining the benefits derived from the ecosystem services, the forgone benefits when nature is compromised, the costs of executing the protection, restoring and conservation measures, the tangible outcomes that is related to the intervention measures.

As resources are limited, it becomes essential to be strategic in allocating them for planning purposes. Details in Figure 10 are a preliminary list of the next steps for each of the financing mechanisms, some of which can be combined to minimize time and expenses. Given that economic valuation for example, can be time consuming and expensive, it might be strategic to identify the types of ecosystems services that will be the focus of economic valuation in sites that can be used as representatives of specific coastal and marine ecosystems and sub-ecosystems. The preconditions to address the legal and institutional issues can perhaps utilize existing channels and the multiple national, regional and area-based committees and working groups.

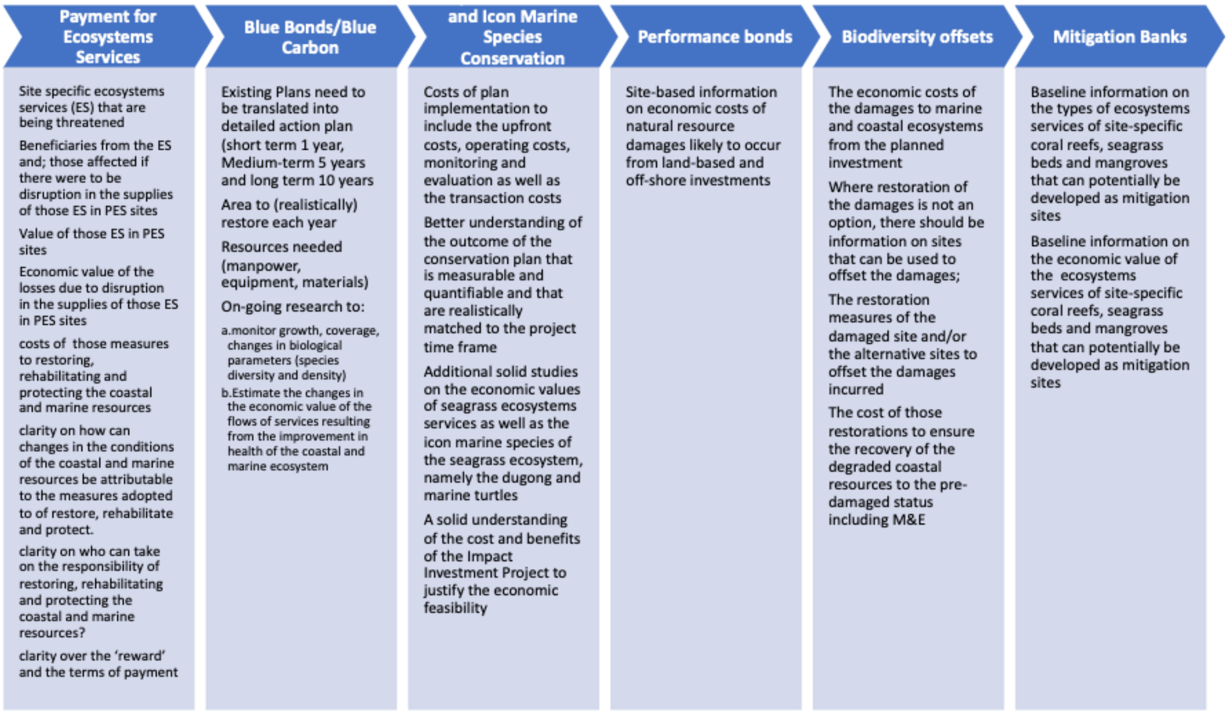


Figure 9: Information gap for implementing selected financing mechanism

The financing instruments discussed can be said to be interrelated and categorized as shown below into those that essentially create demand for conservation measures and those that represent the supply side. The three instruments on the demand side include biodiversity offsets, performance bonds and blue bonds. The requirements that investors and developers create no negative impacts on coastal and marine resources in principle would create demand for conservation measures that can offset the impacts. How will investors offset? If the remedial measures cannot be undertaken on-site, then the mitigation banks provide a channel to off-set through the purchase of the mitigation credits. . In between financial instruments such as Impact Investment and PES essentially link the demand and the supply side. Impact Investment can be a modality to package the planned conservation measures in ways that are more attractive to potential investors in the private sectors and the financial sectors. In restoring and rehabilitating coastal and marine habitats, those who are involved are in fact service providers in the PES scheme or using the Impact Investment terminology, outcome payers.

Figure 10: The next steps for implementing selected financing mechanisms

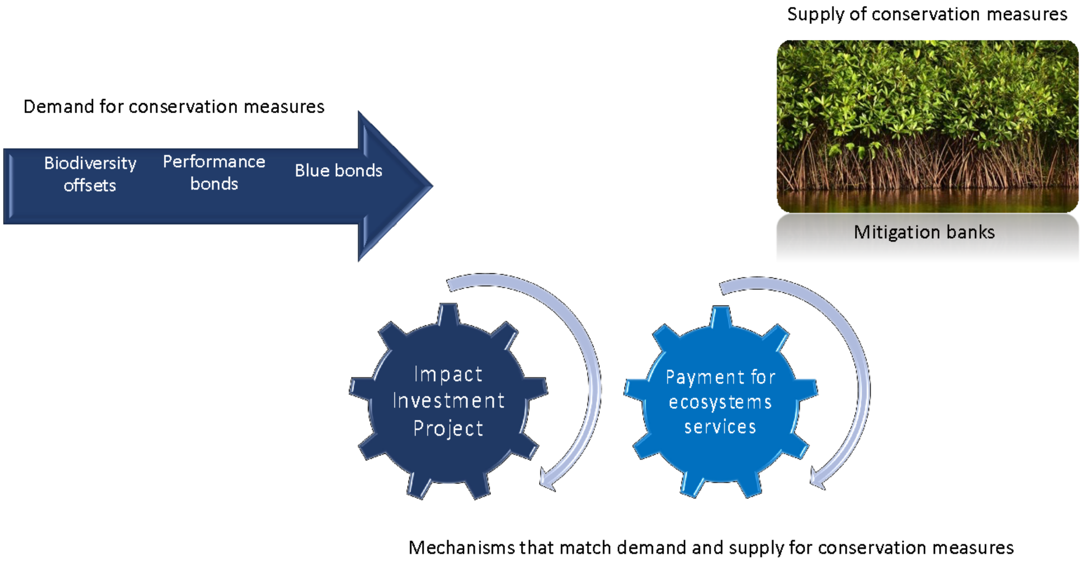


Figure 11: The complementarity of the potential financing mechanisms

To conclude this section, it is essential to emphasize that the economic dimension of biodiversity and ecosystem services is closely linked with the biophysical aspects as discussed in Section 5.2 and 5.3 of this scoping report. In Figure 12 below, in the absence of intervention measures, there is an assumption that the ways in which humans benefit from ecosystem services as well as the impacts from production and consumption will result in the decline of the values of the ecosystem services over time. The decline could be small as in Path 1, moderate as in Path 2 or severe as in Path 3. At period T_5 when some intervention measures are introduced to reverse this declining trend, the timing may be too late to stop the declining trend but at least the interventions do result in reducing the impact. This is depicted by Path 4. A more optimistic scenario is depicted by Pathway 5 in which intervention starts in T_5 but the outcome is only realized in period T_6. Note however, that recovery only peaks at a level after which period, subject to there being no addition adverse impacts, the ecosystem services remain constant.

Perhaps the best-case scenario is Pathway 6 where after T_6, the ecosystem services start to increase but note here too that after a certain period the benefit from the ecosystem services also reaches a ceiling from which point there is no further increase. In principle, the economic benefits are the difference between the ecosystem value '*with*' and '*without*' intervention. The challenge is there is always a host of assumptions which have to be made particularly on the biophysical part of the analysis to analyze which will be the most likely pathway without intervention. Clarity from the natural sciences will also provide the answers as to what feasible intervention is possible given the state of the knowledge and technical know-how.

It is only when the science is clear that the economic analysis can follow. Apart from throwing some light on what the economic values of the ecosystem services are, the contribution of the economic analysis could be to determine which package of technical solutions will offer society the highest net benefits when all the interests of stakeholders have been taken into account. Finally, the optimal answer from the natural sciences, and the answer from the economic analysis over what is the best option for society may have to overcome the institutional and legal barrier.

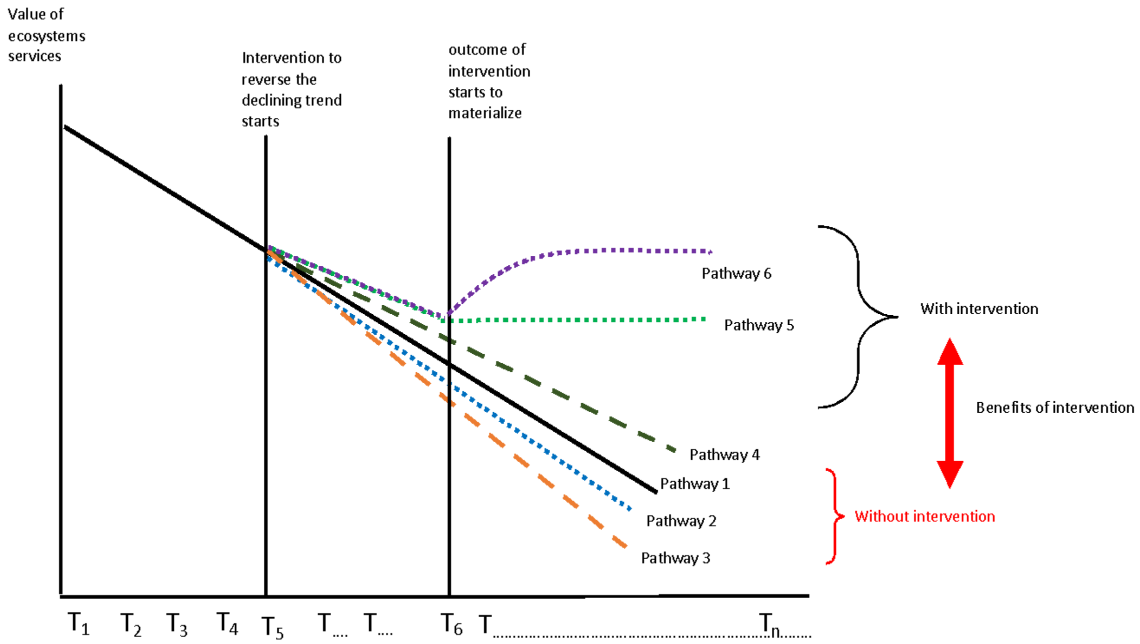


Figure 12: Development Pathways and linkages between the natural science and the economic analysis.

5.4.4 What is realistic for Thailand and what will it take to get there

The table above is an initial list of economic instruments that will be explored further in the NEA. Not all of the economic instruments reviewed will be feasible for adoption in Thailand, given the differences in the legal and institutional context. This section of the report will be a preliminary analysis of the pros and cons of the economic instruments reviewed. The results will highlight the economic instrument(s) that can potentially be adopted as well as the opportunities and challenges involved.

5.4.5 What are the costs of inaction? Is inaction a choice?

The discussion in this section of the NEA scoping report can only introduce the conceptual framework for understanding the differences in the economic value of ecosystem services under the description of the preliminary costs of Business-as-Usual pathways which are contingent upon projections of the changes in the biophysical conditions and how this is linked to the flow of services from coastal and marine ecosystems. This will set the theme for the Technical Report which will draw upon some of the literature reviewed to put forward a case that shows the cost of inaction is greater than the costs of the damages to the stocks and flows of ecosystem services thereby justifying the economic feasibility of conservation investments.

5.5.1. Introduction

In Thailand, Chao Lay (Sea People or former sea nomads) and local fishers especially small-scale fishers who use small boats and simple fishing gear have lived and made livelihoods around the sea and coastal areas for a long time. These ethnic and local communities have ways of knowing the surrounding nature and have accumulated and passed on Indigenous and local knowledge (ILK) that enables them to live sustainably. However, rapid change that comes with both "development" and "conservation" have major impact on community livelihoods.

While ecosystem and biodiversity assessments are often viewed as the work of scientists that requires expertise and elaborated tools in modern laboratory, recent academic and practical works have shown that ILK can contribute to further understanding the changes in ecosystems and biodiversity as showcased by IPBES assessments. Although ILK is often tacit, undocumented, and not systematically tested, it is based on long-term observation and from real-life experiences.

Apart from the contribution that reflects the closeness and observation to the changes of nature, ILK also carries values that come from their connection with nature. Many coastal communities refer to the sea as their 'rice pot' or 'life-line'. This creates an emotional attachment and a common duty to protect natural resources that are both important food sources and the source of community and spiritual security. Chao Lay and small-scale fishers have a deep respect for nature. There are sacred areas that actually serve as modern-day conservation zones. Although these are not officially declared and regulated like state conservation areas, these areas have strict customary management and rules. As such, there is a strong connection between sustainable living and inclusive development.

5.5.2 The importance and contribution of ILK in additional understanding of ecological "services" and in the assessment of marine ecosystem change in Thailand

i. **ILK is a significant part of the multiple evidence-based (MEB) approach.** In addition to science-oriented ways of knowing and ways of assessing ecological services and change, ILK as largely undocumented historical data from long-term observation and real-life experiences, can help inform ecological status and change.

ii. **ILK and practices are part of multiple values in ecosystems and biodiversity**. There is a need to recognize and endorse multiple value systems or value pluralism in Thailand rather than quantifying monetary or market value alone. ILK and such alternative valuation system highlight the importance of realizing the concept like "Nature as Culture" in addition to Nature for Nature and Nature for Society. The "other" valuation systems and their relevance towards ecosystems-based policies need to be recognized.

iii. **ILK has the underlying principle of ecosystem stewardship expressed through customary management and rules**. There is a strong connectivity between sustainable livelihoods and sense of collectivity, reciprocity and mutual trust in ethnic and local communities. In the Thai context, Sufficiency Economy Philosophy (SEP) may be the parallel concept that links sustainability with the culture of moderation and conservation.

iv. **ILK is generally adaptable and innovative**, yet the basis remains on human sense-perception knowledge of ecosystems with selective and reasonable use of technology. The proximity and intimacy of ethnic and local communities with nature helps entail the continuation of ILK, as highlighted in points ii and iii, and due to the innovative capability within the communities, ILK may serve as a key component for sustainability transformation.

5.5.3 Review of the work on sea peoples of southwestern Thailand

The past research work on sea peoples of southwestern Thailand represents cases that are relevant and useful for carrying out NEA in Thailand in the aspects of marine ecosystem assessment. As ethnic communities who have lived in and lived off coastal and marine environment for several hundred years, the sea peoples (Chao Lay) have roles in sustainable use and stewardship of natural resources (Arunotai, 2006a). Nowadays, several areas where they have lived, fished and foraged have been declared national protected areas in the forms of national park, reserve mangrove forest, and environmental protection zones, which means that the ecological health of their formal home and foraging grounds remains intact despite their previous occupation.

The Chao Lay's ways of knowing and ways of life reflect ILK that has an important contribution to assessing ecosystem services and biodiversity . The Chao Lay elders and adults are able to keenly identify changes in their physical and biological surroundings due to these two reasons:

1) Since the Chao Lay are the original inhabitants in the coastal and island areas in Thailand for at least 200 years, there exists a collective or social memory of the land and sea that has been passed down in the form of toponyms, tales, songs, and even individual stories from first-hand experiences. In addition, in the old days Chao Lay rarely made changes to their local environment apart from cutting some wood and bamboo to build boats or temporary huts, so they easily recognize changes in the areas that they stayed or frequented. However, many areas that they used to access are now off-limit due to conservation, development, and privatization of land.

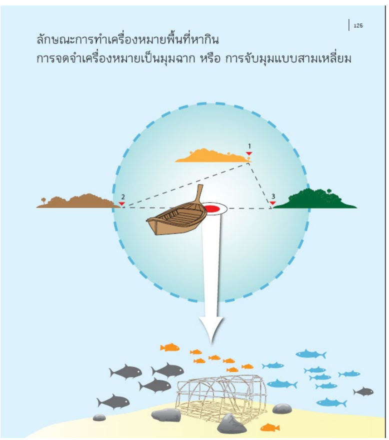
2) Chao Lay livelihood activities in the sea were mostly through diving, both free diving (Moken) and hookah diving (Urak Lawoi), so they are able to observe and feel the underwater surroundings like temperature of seawater, the currents and other occurrence, the conditions of coral reefs, fish, and other marine animals, etc. Again, nowadays when the fishing and foraging areas become limited and the fish and marine animals become scarcer, the Chao Lay have been pressured to use more sophisticated fishing equipment and the younger generation are less knowledgeable and less observant of their natural environment.

The earlier study on climate change risk and adaptation also highlights ethnic and local communities' abilities to recognize environmental changes (Arunotai, 2015). The (direct and indirect) effects of climate change have been deeply felt by several ethnic and local communities in Thailand. The study focused on two groups – the Karen in northern Thailand and the Moken of Surin Islands in Phang Nga province and other Chao Lay people in several southern provinces. The Chao Lay observed the change in local winds and monsoon patterns, the decline in rock oyster population especially during very warm periods, and unusual surges or drops of certain species, etc.

The study stresses that felt effect of general environmental and climate change has been exacerbated by development policies like promoting monocrops in the highlands by the state and private companies, and the development of large tourism infrastructure on seaside lands. On the other hand, accelerated environmental degradation and heightened climate change have compelled conservation departments to come up with more strict regulations, plans and implementation for the expansion of protected areas.

It is a paradox that the policies to conserve biodiversity and ecological health further deny ethnic and local communities access to their traditional spaces (Bates and Trakarnsupakorn, 2021) and become threats to ILK which is the very essence of ethnic and local communities' sustainable living. When ethnic and local communities become marginalized because of these factors, then they became vulnerable to losing their lands, livelihoods, and cultures, and eventually had to find other means of livelihoods out of their expertise and experiences (Arunotai et al., 2007a). This can take them away from their natural environment and can have a great impact on the maintenance and passing down of valuable ILK.

In ongoing research to develop a Moken "culturally protected area" or "protected cultural area" on the Surin Islands, a survey on the Moken opinions was conducted in 2022 pertaining to the status of certain resources and the change in natural occurrences on the Surin Islands. The results from this questionnaire will be compared with the earlier study around 2004-2005 (Arunotai et al., 2007b), and analyzed in the ILK section of the assessment report to understand the perceived change and explore further how these changes could be explained and monitored.



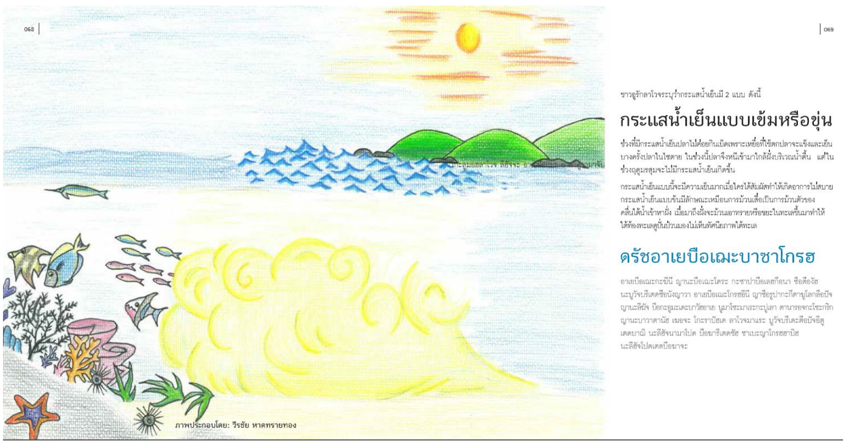


Figure 13: Examples of ILK studies and materials

5.5.4 Recommended participatory methodologies for mobilizing and mapping ILK

ILK work in the Thailand NEA plans to co-create methodologies for participatory processes, firstly by reviewing existing methods in collecting data and bridging scientific knowledge and ILK. In "Bridging Indigenous and science-based knowledge in coastal and marine research, monitoring, and management in Canada", Alexander et al. (2019) reviewed published studies that attempted to bridge Indigenous and science-based knowledge in research on coastal marine ecosystems in the context of Canada's three coastal and marine regions of Arctic, Pacific and Atlantic.

They found that several methods have been used in acquiring Indigenous knowledge (interviews, workshops, participatory mapping, document review, survey, participant observation, focus groups, and oral history), and also several methods in collecting other scientific data (document review, numerical counts, abiotic sampling, mapping, tissue sampling, dissections, mark-recapture studies, simulation, survey, natural history observations, interviews, remote-sensing, and expert opinion). As for the ecological scale of research, the majority of the studies reviewed in Alexander et al. (2019) focused on species, with fewer studies on ecosystems and the least carried out at ecological community scale. In this scoping phase of the NEA, the team used several methods (Figure 14) including mapping, oral history, interviews (both individual and group interviews), and focus group discussions (FGDs).

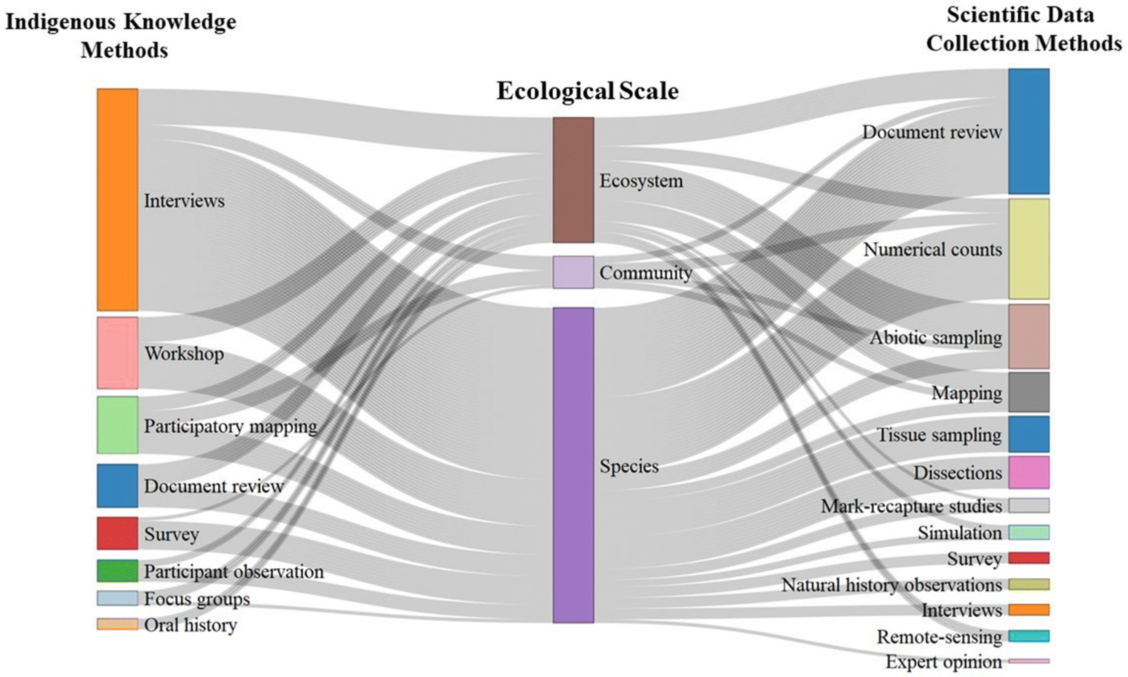


Figure 14**:** Diagram shows a relationship between Indigenous Knowledge methods, ecological scale, and scientific data collection methods, from Alexander et al., 2019

The participatory method focused on mapping. With lessons learned from community projects conducted by Sirindhorn Anthropology Centre (SAC) and Chulalongkorn University Social Research Institute (CUSRI), participatory mapping works best, as hand-drawn maps are an instrument or a media for putting data, drawings, notes, etc. together in one place. Flip-chart maps are inexpensive and convenient, and they serve as common visual "boundary object" for mobilizing diverse information, observations and knowledge.

Although participatory mapping of land-based or land-oriented environments, resources and communities has become widely practiced, there has been less experience with sea-oriented or underwater mapping. As mentioned, the Moken and the Urak Lawoi divers have in-depth (literally and figuratively) knowledge of their fishing and foraging areas, so it would be valuable to delve into their knowledge and observations and develop visual representations that can be interpreted and analyzed as a part of ecosystem and biodiversity assessment.

Small-scale fishers also have knowledge about marine topography and living environment as this is part of their "invisible" daily livelihood. However, this knowledge has always been neglected in policy, planning and management. An example would be the oil spill in Rayong province (in January 2022), which clearly demonstrated this fact, as the clean-up decision did not recognize the roles of small-scale fishers in providing insight into the environment of their affected fishing grounds. Although small-scale fishers do not have expertise in the technicality of oil clean ups, they observed how the method of oil dispersant (employed after the previous oil spill in 2013) can have a long-term impact on the marine animals on the seabed. One fisherman mentioned different sites in the marine topography (spawning area, fish aggregation area, etc.) that may become affected by the similar dispersant method in 2022 (Wattana, 2022). This knowledge of underwater sites and habitats is totally ignored.

After participatory mapping and participatory data collection during short field surveys conducted in 2022, the team synthesized the data and design methods for two-way communication during a series of workshops with ethnic and local communities and/or intermediary organizations. These workshops were held in December 2022.

For the expert evaluation phase of the NEA, methodologies for participatory expert evaluation have been selected to facilitate communication and allow for joint learning, and for pinpointing special issues on ecosystem services, status and change in the target communities. The methods selected are as follows:

- Public communications on NEA processes in Thailand aiming at various groups of stakeholders (core team) and ethnic and local communities (ILK team).
- Select communities or sites for potential ILK evaluation, noting that their "Free, Prior and Informed Consent" must be obtained in order to access their knowledge.
- Organize Focus Group Discussions (FGDs) or small group meetings with ethnic and local communities and/or intermediary organizations to collect preliminary data on ecosystem services, status, changes and impact on ethnic and local communities and ILK. Identify knowledge/data gaps and key policy questions.
- Identify participatory research case studies for potential use in the expert evaluation stage of the NEA

5.5.5 General data from field surveys

Field surveys conducted in 2022 focused on small-scale fishing communities in Nakhon Si Thammarat and on Chao Lay communities and small-scale fishing communities in Phuket. From the data collected by the team during the scoping phase, small-scale fishing activities have many forms and can be carried out with a variety of tools. These all connect to ILK, which is derived from cumulative everyday experiences and observations, and learning from older generations. Small-scale fisheries make use of coastal areas from sandy or muddy beaches and rocky shore areas to reef flats, mangroves forest and canals, and in the sea. They usually have their own categorization of marine zones signifying different perceptions and uses of space. Ethnic and local communities like Chao Lay have toponyms in their own language that reflect landscape and seascape features, natural resources, group or individual activities relating to the area, etc. However, these are gradually falling out of use and forgotten due to the replacement of Thai names, and later, of names of hotels and other businesses located in that coastal area. These coastal communities also make use of beach and coastal or island forest areas for wood, food and medicine.

Figure 15: Satellite map of Phi Phi Don Island (Krabi Province) showing ethnotoponyms that spread throughout the island.

Fishers who collect fish, crab, and other sea animals with bare hands are quite rare but are still found among older males. Although they can afford fishing equipment like traps and nets, they prefer to use bare hands as they have ILK that enables them to make adequate living without extra cost of money or time (in buying, maintaining, repairing and replacing fishing equipment). Those with long-standing experience and expertise still choose this traditional method as they have knowledge and keen eyes and only depend on a few simple items like net bags and long hooks.

Figure 16: Right, fishing by putting small fish net along the shallow water line and then collecting the net during the incoming tide (Phang Nga). Left, collecting marine animals and edible plants around mangrove area (Phuket).

The field data reveals that each community has distinct ILK and some that have experienced outside pressures have also come up with innovative ways of regenerating fish and marine animal stock like creating fish aggregation devices and crab bank. The table below lists ILK and pressure/threats to ILK and sustainable livelihoods based on the survey results in 2022 and from ethnic and local communities' perspectives.

Table 8: Showing ILK and important issues found in each survey area.

Community	Important issues	
	ILK	Threat to ILK and sustainable livelihoods
1. Ban Laem Phak Bia Community (Petchaburi)	ILK regarding observation of waves, winds, currents. Creation of fish aggregation devices from local materials. Establishing crab bank.	Large-scale, unsustainable fisheries. Marine/freshwater waste and water pollution coming from factories/farms/chemical-used agriculture land along the river.
2. Ban Thung Noi Community (Prachuab Khirikhan)	Sustainable fisheries revitalization. Development of crab banks, and markets that connect urban consumers.	Unsustainable large-scale fisheries. Fisheries and development policies.
3.Ban Thung Rak Community, 4.Ban Thab Tawan Community 5.Ban Thab Pla Community (Phang Nga)	Traditional methods of the Chao Lay in fishing-gathering. Local toponyms.	Degradation of marine resources.
6.Ban Nai Thung Community, 7.Ban Sabua Community, Ban 8.Na Thab Community (Nakhon Si Thammarat)	Du Lam (fishing by listening to fish sounds). Passing down of marine and sustainable fisheries knowledge. Building fish houses (fish aggregation) and organizing crab bank activities.	Unsustainable large-scale fisheries. Fisheries policy and unrestrained development/adaptation to changes from onshore areas and irrigation dams.
9.Ban Ao Kung Community, 10.Ban Tha Sak-Para Community 11.Ban Khlong Kamphaeng Community (Phuket)	Local communities' toponyms. Passing down of marine and sustainable fisheries knowledge and customary management, and campaigning against activities that threaten sustainable livelihoods. Incorporating new techniques in Dollfus' octopus fishing.	Shrimp farming activities. Fisheries and irresponsible development policies, especially promoting (over)tourism and marina infrastructure.
12.Ban Sapam Community 13.Ban Laem Tukkae Community (Phuket)	Traditional methods of the Chao Lay in fishing-gathering. Local toponyms.	Degradation of marine resources from urban and tourism development, shrimp farms. Inadequate housing and public space. Lack of life amenities.

5.5.6 Gaps in knowledge, data and practice

Basically, research among marine ethnic and local communities is mostly focused on natural resource management, conflict from policy and implementation, and community rights (science-based, social-science based and multi-disciplinary) or ILK *per se* (social-science based). There is still a lack of compiled knowledge on ILK in ecosystems and biodiversity that can inform multi-scalar and interdisciplinary assessment. Participatory ecosystem assessment by ethnic and local communities in formal research is still rare.

5.5.7 Identify key policy questions regarding ILK

Es of policy questions regarding ILK are as below:
a. How could a set of ILK health and other socio-cultural indicators be added in formal national development indicators?
b. Do we need public policy support for multiple knowledge systems for a more participatory planning, management and monitoring?
c. How do we promote ILK and its roles in citizen science and knowledge co-creation?

From the field survey data, a series of key ILK questions for each section of the assessment are proposed:

Section 1: Status, Trends and Future Dynamic of Coastal and Marine Biodiversity and Ecosystems Services Underpinning Nature's Benefits to People

- What does nature (coastal, marine, island etc.) mean for ethnic and local communities? What are the relationships between humans, nature and culture?
- How are the status, trends and future dynamics of coastal and marine biodiversity and ecosystem services expressed in the language and conversation of ethnic and local communities?
- What roles do ethnic and local communities and ILK have in providing insight into the status and trends of coastal and marine biodiversity and ecosystem services, and in developing related indicators?

Section 2: Biodiversity and Ecosystem Services: Socio-economic Development and Human Well-Being

- What are key definitions of "development" and "human well-being"? Are there any differences in such definitions and perspectives as defined and seen by ethnic and local communities and other groups?
- What can we learn about "development" and "human well-being from ethnic and local communities who have lived or used to live harmoniously in the ecosystems for a length of time?
- Would national development indicators be more comprehensive if a set of ethnic and local communities' health, including ILK and other socio-cultural indicators be added?

Section 3: The concept of multiple values of biodiversity and ecosystem services in the age of the Anthropocene

- What are the multiple value systems and multiple knowledge systems, and how could policy makers and the public be more informed about the importance of these?
- How would ethnic and local communities' valuation of "nature" or "biodiversity and ecosystem services" bring depth into the analysis of the benefits of services provided by coastal and marine ecosystems?
- Do we need public policy support for multiple value systems and multiple knowledge systems for more participatory planning, management and monitoring?

Section 4: Direct and Indirect Pressure and Impacts on Coastal and Marine Biodiversity and Ecosystem Services.

- What are the most important drivers, pressures, impacts and threats on "nature" or "coastal and marine biodiversity and ecosystem services" encountered by ethnic and local communities? What are the threats to ILK? And how could these be alleviated?
- How could ILK be accepted, acknowledged and promoted in national policies in an equitable/fair manner, in order to increase conservation efforts and to decrease pressures and impacts on marine biodiversity and ecosystem services?
  - How can we promote policies and secure regular state funding in support of progressive and ecologically sound initiatives from ethnic and local communities or intermediary organizations and how to mainstream or upscale those in the long run?

Section 5: Options for Policies, Governance and Institutional Arrangements for Biodiversity and Ecosystem Management

- What are the structure and functions of ethnic and local communities' "traditional" governance systems and how can these contribute to securing community peace and sustainable management of coastal and marine resources?
- How do we include cultural and livelihood impact assessments of small, marginalized ecosystem-based communities in the design/approval of development and conservation policies/projects?
- From the status of existing ILK in marine ecosystem in Thailand, how do we build institutional capacity (for different sectors and at different levels) in dealing with "unsustainable development"?

5.6 Options for Policies, Governance and Institutional Arrangements for Biodiversity and Ecosystem Management

5.6.1 Rationale and context

Coastal and marine resources are critical to people, nature and the economy, and are a focus for the emerging sustainable blue economy. Given the economic and social importance of Thailand and marine areas, their governance, and in particular, how decisions are made about coastal and marine resources, is an important issue for Thailand.

This chapter provides an overview of coastal and marine governance at the national level and examines in more detail how it operates to support biodiversity and ecosystem services. Institutions and governance are the underlying causes of changes and are central to the IPBES conceptual framework because of their crucial role, in influencing all aspects of the relationship between people and nature. Based on the IPBES conceptual framework, institutions and governance are considered indirect drivers, because in the vast majority of cases, they do not affect nature directly but rather through their effects on direct anthropogenic drivers of biodiversity and ecosystem. '*Institutions encompass all formal and informal interactions among stakeholders and social structures that determine how decisions are taken and implemented, how power is exercised, and responsibilities are distributed. Various collections of institutions come together to form governance systems at different scales'* (Diaz et al., 2015).

Institutions and governance systems determine, to various degrees, the access to, and the control, allocation and distribution of components of natural and anthropogenic assets and their benefits to people.

Examples of institutions vary, which are systems of property and access rights to land, legislative arrangements, treaties, customary laws, informal social norms and rules, and international regimes (Diaz et al., 2015). Moore et al., (2011) refer to government agencies, non-government organizations, private sector associations, and community-based organization are among the many different kinds of institutions that may have a role in making and implementing decisions. Interestingly, economic policies are the institutions that play a significant role in influencing people's perception about nature's benefits, and their behavior and, thus, their decisions about the way they interact with nature. Three components (statutory and customary norms, institutions, and processes) and the principles of accountability, participation, transparency, and predictability, also form a practical governance framework. On the basis of this framework, the Thailand Environment Institute under the auspices of the Mangroves for the Future (MFF) initiative carried out a desk-based review in assessing the national coastal governance system for the first time in 2007 (TEI, 2008), and the second time in 2014 (Satumanatpan, 2015). An in-depth field study of governance of marine resources on Koh Tao also examined how local people on Koh Tao understand governance, how they participate in it, and the impact they perceive it has on their lives and livelihoods (Satumanatpan et al., 2017).

Clearly, effective governance has been identified as one prominent factor that can enhance sustainability (or biodiversity and ecosystem services) and resilience of marine systems to changes (Hay, 2013; Hay et al., 2013; Polido et al., 2014; Singh, 2014; Fernandes et al., 2015; Farhan and Lim, 2013) and communities (U.S. Indian Ocean Tsunami Warning System Program, 2007). The natural resource managers in most countries of the Asia Pacific region have increasingly realized that community-based co-management and strong leadership are the best ways to prevent depletion of bio-resources and degradation of ecosystems (IPBES, 2018). The majority of the developing countries in the Asia-Pacific region commonly face the problem of the ineffectiveness of implementing environmental policies. The reasons behind this include financial shortages, overlap of administrative authorities, poor communication, and a lack of economic incentives to control pollution and restore degradation. While many countries have made substantial progress in environmental protection legislation over the last decade, the issues that could still be improved concern the actual implementation of these laws. For instance, the lack of strong enforcement and effective management are key issues found in several coastal environmental protected areas in Thailand (Satumanatpan et al., 2014, Satumanatpan et al., 2017). Another common problem also found in Thailand is the fragmentation of responsibilities for protected areas between ministries (Satumanatpan and Chuengpagdee, 2022). Additionally, Thailand's governance structures are diverse, but environmental governance has not often fully adapted to the new pressures from globalization and economic development due to the lack of flexibility of centralized governments or these governments prioritizing economic development over environmental issues.

Given the critical role of governance in aiming to maintain and enhance nature's benefits to people, this chapter of the NEA will assess biodiversity and ecosystem services (BES) from a governance perspective by focusing on marine systems. Resilience is the key concept used in assessing whether the existing marine governance (social-governing system) provides a consistent and comprehensive response to dynamic changes. The concept recognizes the marine systems as the social-ecological system consisting of human (social) and natural processes that connect through space and time and are therefore governed holistically in order to generate sustainable outcomes. Several factors that support the social-ecological systems' resilience or system adaptability (e.g., Folke, 2006; Walter and Salt, 2006; Ebbesson, 2010) can be summed up in four elements (Ebbesson and Hey, 2013): 1) Institutions and social systems that are adaptable to change; 2) Institutions that are transparent to allow for wide participation; 3) Efficient multi-level governance; and 4) Social structures that encourage learning and adaptation without restricting possibilities for future development. In this context, it is suggested that coastal governance systems possessing these four adaptive factors/conditions could improve the adaptive capacity or resilience of the coastal and social systems [adaptive capacity is related to, and sometimes equated with resilience. (Turner et al., 2003; Smith and Wandel, 2006; Gallopin, 2006)].

The main governance elements in focus for this study are policy and institutions that include legal frameworks and some primary instruments. The latter are focused on community participation, marine protected areas (MPAs) and marine spatial planning (MSP) as the examples.

This chapter will aim to address the following questions:

- What are the current policies and institutions that support BES management and conservation for marine systems?
- What are the roles of various actors in the governance of BES, particularly in mainstreaming BES in sustainable development?
- Given the existing systems of governance, what are the governance systems that could enhance BES management and conservation in relation to the resilience factors?

5.6.2 Methods used

For analyzing whether the existing coastal governance system support the marine biodiversity and ecosystem services in Thailand, we are employing the following process of work:

We first undertook a desk review of the policy/directions relevant to biodiversity protection (section 5.6.3). For the global and regional scale, the review includes, for instance, the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs), the ASEAN Socio-Cultural Community Blueprint (ASCC), the Declaration on ASEAN Post-2015 Environmental Sustainability and Climate Change Agenda, and the Sustainable Development Strategy for Seas of East Asia (SDS-SEA).

For the national scale, we will review the published government policy and legal basis for governing marine resources in Thailand. The documents include Thailand's 2030 Agenda and Sufficiency Economy Philosophy (SEP), The 20-Year National Strategy (2017-2036), the National Reform Plan, The 13th National Economic and Social Development Plan (2017-2022), the National Environmental Quality Management Plan (2023-2027), The Climate Change Master Plan (2015-2050), the Master Plan for Integrated Biodiversity Management (2015-2021), and the Biodiversity Management Action Plan 2017-2021.

In terms of the national legal framework, we will review a number of significant laws and regulations that provide enabling conditions for supporting the conservation of biodiversity within the marine systems. Major relevant laws include the following: the 1992 National Environmental Quality Act and the second amendment in 2018; the 2015 Promotion of Marine and Coastal Resources Management Act; the 2015 Royal Ordinance on Fisheries; the 2019 National Park Act; the 2019 Maritime Interest Protection Act; the 2020 Regulation of the Prime Minister Office on Conservation and Utilization of Biodiversity; and the Draft National Biodiversity Act. We will provide the essence of reviewed national laws within two sections: Section 5.6.4 (a) explains details of significant law's provisions as supporting the BES; Section 5.6.4 (b) delivers a clear picture of multiple government agencies as well as established committees and sub-committees to serve as coordinating mechanisms for governing marine resources.

In addition to the legal framework as one among others under the current institutions, we also pay attention to review a number of particular instruments that have been used in supporting the conservation in several coastal areas. Community participation and marine protected areas (MPA) have been clearly stated by diverse legal frameworks. Another instrument, marine spatial planning (MSP), although without unclear legal authority for the time being, it has been promoted through several national strategies since 2015. Information related to conservation cases using these tools will be derived from Marine and Coast National Reports (2016-2023), and the author's participatory and observation through relevant National Sub-Committee meetings over the last five years. Information and discussion about community participation are to be provided in section 5.6.4 c), and MPA and MSP are to be shown in section 5.6.5. MPA and MSP have been incorporated broadly in ecosystem-based management concept relevant to land-sea interaction, which is widely recognized as a key concept underpinning the SDGs (IRP, 2021).

We also synthesize and examine different policy ideas, institutional arrangements and possible options for decision makers in response to the drivers and scenarios set out in the previous chapters (chapter 5.1-chapter 5.5). We will analyze the coastal governing systems, including local/customary approaches, to gain a deeper insight into whether and how they are supporting or presenting features of adaptive strategies in supporting coastal BES. Governance options that support BES could be diverse, e.g., policy instruments, market tools, conservation and management practices. This chapter will also analyze further challenges for sustainable use and conservation in specific coastal areas (sites not selected yet). Finally, we suggest possible policy and governance that could support or enhance the BES of marine systems.

5.6.3 The policy basis for supporting coastal and marine governance

a) Global and Regional Development Policy and Direction

- The 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs)
- Convention on Biological Diversity
- Kunming-Montreal Global Biodiversity Framework (KMGBF)
- Ramsar Convention on Wetlands
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- The ASEAN Socio-Cultural Community Blueprint (ASCC)
- Declaration on ASEAN Post-2015 Environmental Sustainability and Climate Change Agenda
- The Sustainable Development Strategy for Seas of East Asia (SDS-SEA)

b) Policies and directions of operations in Thailand

- Thailand’s 2030 Agenda and Sufficiency Economy Philosophy (SEP)
- The 20-Year National Strategy (2017-2036)
- The National Reform Plan
- The 12th National Economic and Social Development Plan (2017-2022)
- The National Environmental Quality Management Plan (2017-2021)
- The Climate Change Master Plan (2015-2050)
- The Master Plan for Integrated Biodiversity Management (2015-2021)
- Biodiversity Management Action Plan (2017-2021)

5.6.4 National Legal and Regulatory Framework

a) National Regulatory Framework

National laws and regulations create the institutions responsible for governance in the coastal zone and marine areas and establish the governance basis for the governance process. The management of coastal resources or biodiversity has been governed by several laws, including:

- Local Government Organization Act (1999) (Royal Gazette 1999)
- Wildlife Conservation and Protection Act 1992 (Royal Gazette 1992) and amendments in 2003, 2014, and 2019 (Royal Gazette 2019).
- National Environmental Quality Act (1992) (Royal Gazette 1992) and second amendment (2018) (Royal Gazette 2018)
- Promotion of Marine and Coastal Resources Management Act (2015) (Royal Gazette 2015)
- Royal Ordinance on Fisheries (2015) (Royal Gazette 2015)
- National Park Act (2019) (Royal Gazette 2019)
- Maritime Interest Protection Act (2019) (Royal Gazette 2019)
- Regulation of the Prime Minister Office on Conservation and utilization of Biodiversity (2020) (Royal Gazette 2020)
- Draft Biodiversity Act (2023)
- Draft Climate Change Act
- Draft Protection and Promotion of Ethnic Groups' Way of Life

b) Government agencies and committees established by law

Based on section 5.6.4 a), national laws and regulations create the institutions for governing coastal and marine systems. These government authorities have created multiple committees and sub-committees to serve as coordinating mechanisms for the coastal and marine governance.

- Major institution/organization arrangements involving in governing coastal and marine resources.
- Relevant committees and sub-committees as coordinating mechanism for conservation BES.

c) Community participation

The current marine and coastal resource management policies have the Act enacted to promote marine and coastal resource allocation B.E. 2558 and issue the regulation for all citizens. This action helps increase the participation of coastal communities and local administrative organizations in resource management. This included in the information provision, listening to feedback and the co-action and follow-up the results. However, in many cases, the communities have no decision to take the necessary and proper measures, so the policy should be reviewed and improved to increase participation in the co-management between the state and the coastal community.

5.6.5 Two primary instruments/mechanisms

a) Marine Protected Areas (MPAs)

At present, the proportion of Thailand's Exclusive Economic Zone (EEZ) managed using ecosystem-based approaches has reached 15.7 % (50,700 km^2). Concerning Marine Protected Areas (MPAs), Thailand has adopted the target of 10% of coastal and marine areas to be protected. At present, the total coastal and marine protected area is about 18,000 sq.km., accounting for 5.6% of Thai waters, encompassing 22 national marine parks, 6 coastal non-hunting areas, 160 sites of reserved mangrove forests, 56 marine fishery sanctuaries, and 6 environmental protection areas. In order to attain 4.4% (14,300 km^2) more of MPAs, a number of potential areas/sites have been targeted for legal proclamation in the coming years. The proposed areas include 4 national marine parks (ca. 450 km^2), 3 environmental protection areas (570 km^2), and many marine and coastal protection areas, i.e. 25 island-groups (6,600 km^2) and one large offshore shelf-break font zone (6,700 km^2).

b) Marine Spatial Planning (MSP)

DMCR is developing a marine spatial planning (MSP) process in the region in an effort to promote the sustainable use and equitable access of marine resources and to reduce tension between different stakeholder groups.

5.6.6 Presentation of governance options

i. Limitations
ii. Policy options
iii. Strengthening existing governance systems

CHAPTER 6. STRATEGIC PARTNERSHIPS AND INITIATIVES

There are many stakeholders are relevant to the NEA including strategic committees and, government organizations, academic institutions, the private sector, non-governmental organizations, international organizations and relevant projects. These stakeholders are relevant at different levels in terms of decision-making, regulating measures, conserving natural resources and as knowledge holders. Stakeholder engagement will play a significant role in the NEA to access data and knowledge and ensure that stakeholder views will integrate and align with policy level. Relevant stakeholders include the following:

i. Strategic committees and working groups: National Committee on Conservation and Utilization of Biodiversity, Biodiversity Technical Subcommittee on Species and Ecosystem

ii. Government organizations: MONRE, ONEP, DMCR, DOF, DNP, MOTS, TAT, NESDB, NSC, DMF, GISTDA

iii. Academic institutions: e.g. CU, MU, RU, KU, PSU, BU etc.

iv. Private sector: e.g. Global Compact, Chevron, PTTEP, SEAFDEC, tourism companies

v. Non-governmental organizations: Fisher Folk Association, SDF, PTIT, Diving Association of Thailand.

vi. International Organizations: UNEP-WCMC, UNEP, UNDP, UNESCO, IPBES, BES-Net, TEEB, PEMSEA, SAEFDEC, FAO, ACB, IUCN, COBSEA.

vii. Relevant projects.

The NEA team has conducted stakeholder activities since April 2022. For example, to promote the NEA project the sub-committee for advice and knowledge management for the national maritime interests under the Office of the National Security Council (NSC) organized a NEA workshop during the 7th Marine Science Conference to draft the scoping report with relevant government organizations, companies, academic groups, and local communities. In the future, the NEA team plan to engage more ethnic and local communities for accessing data and collecting case studies.

Communication is the project's key output; the main goal of communication is to share knowledge and improve collaboration among ILK holders, the public and the private sector. It will lead to a sustained assessment guideline from the bottom up. The NEA process has four crucial phases: scoping, expert evaluation, approval, and use of assessment findings. A communication plan will be developed to identify stakeholders and review the scoping report in the scoping phase. Then, in the expert evaluation phase, the plan is to analyze stakeholders, and organize another trialogue workshop for validating the technical report.

According to the communication plan (Figure 17) the TWG aims to promote the NEA project and communicate with relevant stakeholders through the existing platform and national conference, social media, and fieldwork. Knowledge and NEA findings will spread widely through these channels:

i. Social media such as websites, Facebook, YouTube
ii. Infographic format
iii. Printed copies
iv. Using for educational purposes, including to update curriculum and course materials
v. Citizen science

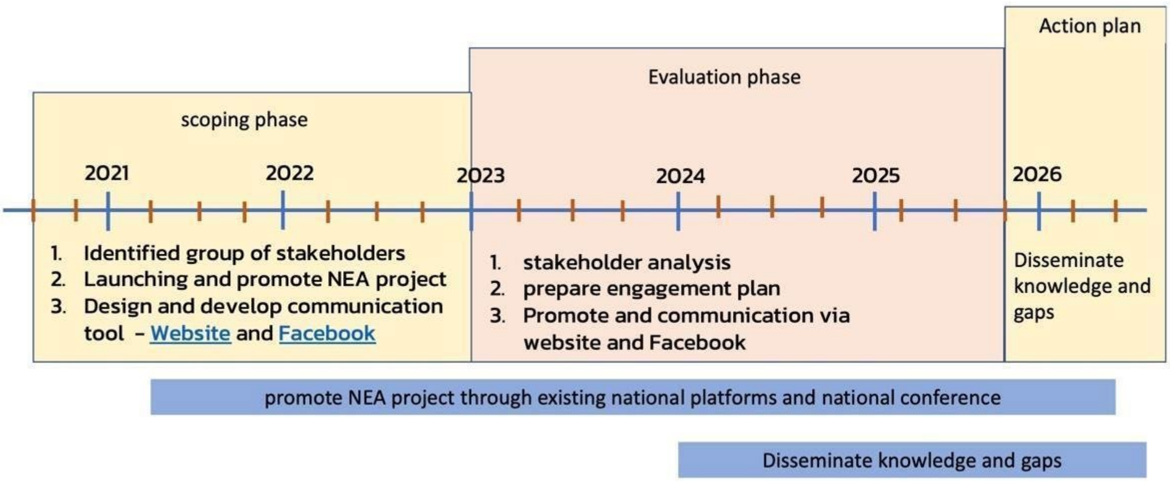


Figure 17: Summary of Thailand's NEA communication plan

CHAPTER 8. CAPACITY BUILDING

The main goal of the NEA project implementation in Thailand is to collect data and evaluate the state of marine biodiversity and its contribution to human well-being. Furthermore, the country expects to encourage the science-policy interface, which is the method by which scientists and stakeholders provide scientific and intrinsic knowledge to be used as a database to determine national policy. Strengthening stakeholder engagement is an effective way to boost the capacity of ethnic and local communities, as well as the private sector and other stakeholders, to participate in the collection methods, monitoring, and evaluation processes. In addition, the NEA seeks to enhance economic tools for managing coastal and marine biodiversity and ecosystem services and collaboration with international organizations and communities to promote the research process and citizen science.

The country team has gained support from UNEP-WCMC through a variety of activities, including providing information and training on the IPBES conceptual framework and methodology approach in workshops and webinars to improve the understanding and use of the IPBES approach and resources in the assessment process. External resource-persons will be invited, as needed, to assist with capacity building and further training. Financial support was provided for the Thailand country team to participate in NEA global workshops to share experiences and lessons learned with other NEA countries.

Thailand NEA project's operational structure (Figure 18) consists of ONEP, the policy focal point, who supports and keeps up to date with policy relevance and implementation, as well as coordinating the Project Steering Committee to provide approval of key outputs, like the scoping report, NEA technical report and the Summary for Policy Makers (SPM).

Our structure also will include Chula Unisearch working as an implementation agency and handling documents and budget. The core team consists of the project director, project manager, project coordinator, and project officer, who oversee the scoping and assessment reports, disseminating reports and fact-finding, and managing the work plan and budget. The core team also includes the project advisor, who will oversee editing the NEA technical report and summary for policy makers. Our team includes a team of lead authors who will contribute to the technical report and ensure integration and coherence. During the expert evaluation and approval phase, an expert team will be selected to help with the evaluation.

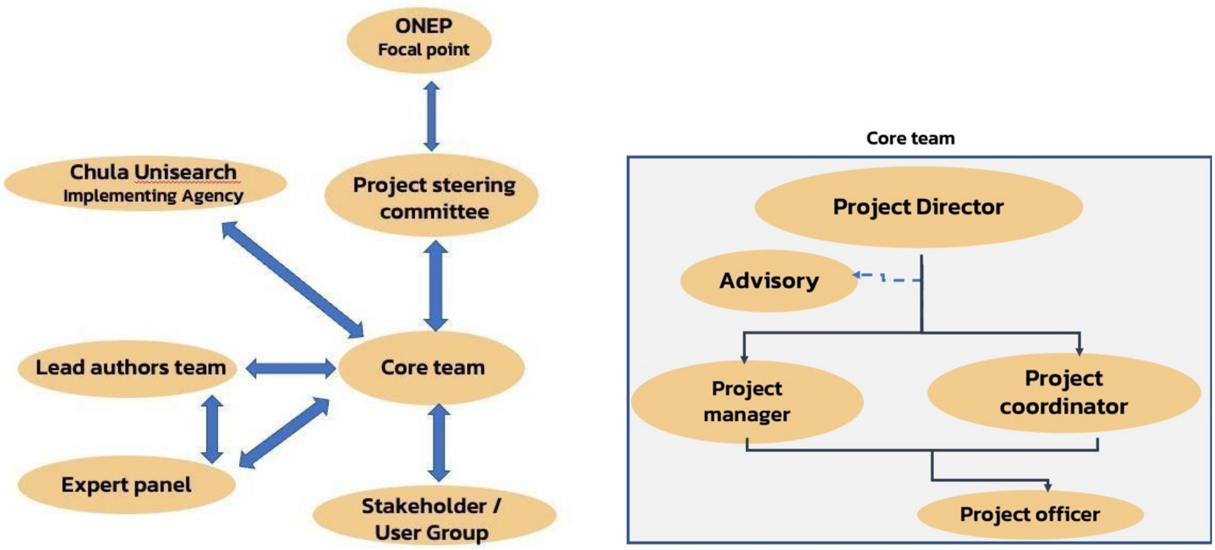


Figure 18**:** Thailand NEA project's operational structure

The Project Steering Committee (PSC) is made up of key government agencies and experts. The main objective of this committee is to build capacity at the national level to undertake ecosystem assessments and support the uptake of assessment findings into national decision-making. The composition of the committee is listed below:

1. Secretary General, Office of Natural Resources and Environmental Policy and Planning (ONEP)
2. Representative from UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC)
3. Representative from Department of Marine and Coastal Resources (DMCR)
4. Representative from Department of National Parks, Wildlife and Plant Conservation (DNP)

5. Representative from Department of Fisheries (DoF)
6. Representative from Office of the National Economics and Social Development Council (NESDC)
7. Representative from Office of the National Security Council (NSC)
8. Representative from Department of Tourism (DOT)
9. Representative from Thailand Science Research and Innovation (TSRI)
10. Representative from Thailand Institute of Scientific and Technological Research (TISTR)
11. Representative from Geo-Informatics and Space Technology Development Agency (Public Organization) (GISTDA)
12. Representative from Center of Excellence on Biodiversity (BDC)
13. Mr. Anuwat Nateewattana
14. Director of Biodiversity Management Division, Office of Natural Resources and Environmental Policy and Planning (ONEP)
15. Biodiversity Management Division Officer, Office of Natural Resources and Environmental Policy and Planning (ONEP)
16. Department of Climate Change and Environment (DCCE) (in process)

Year	2021			2022				2023				2024				2025				2026			
Goals and key activities	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Scoping report																							
Nominated lead authors																							
Consulting with lead authors (LA)																							
Kick-off meeting																							
Writing workshop																							
Stakeholder engagement in Marine Science Conference 7th																							
Design key policy questions and methodologies																							
Finalize 1st draft scoping report by LA																							
Final draft scoping report submitted to UNEP-WCMC & revised																							
Public event for discussing scoping report																							
Seeking scoping report approval from PSC																							
Submit final report																							
National platform established																							
Review existing national platforms																							
Analyze relevance and linkage in existing national platform																							
Promote NEA project to national committee that relevant with NBP																							
Setting up PSC																							

Year	2021			2022				2023				2024				2025				2026			
Goals and key activities	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Assessment technical report released																							
Prepare 1st technical report																							
Review and provide input to technical report by core team																							
Purpose 2nd technical report																							
Review and provide input to technical report by core team																							
Submit draft 3 to UNEP-WCMC for comment																							
LA finalize technical report																							
seeking approval from PSC																							
Translation of technical report																							
Submit final report																							
Trialogue workshops																							
Mini-trialogue																							
1st trialogue workshop																							
Field visit																							
Selection of pilot sites																							
Scoping phase field visits																							
Assessment phase field visits																							
Communications (Plan for the dissemination and use of assessment findings)																							
Identified group of STK																							
Prepare 1st draft communications & outreach plan																							
Design and develop communication tools - Website and Facebook etc.																							
Layout and design policy brief																							
Further stakeholder analysis																							
Plan for use of findings																							
Submit the communication tools to UNEP-WCMC for comments																							

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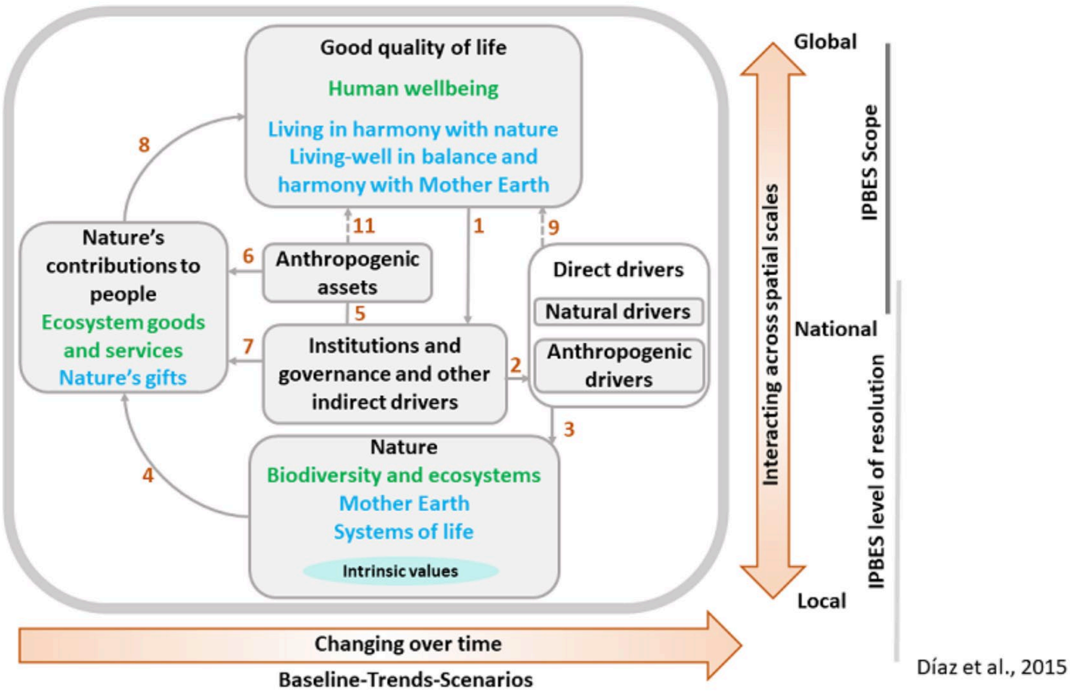
APPENDICES

Annex 1: IPBES conceptual framework



Annex 2: Indicators of marine ecosystem components, processes, and ecosystem services

Marine ecosystem: Components	**Indicators (examples of units)**
Habitats and species	Abundance (no.); biomass (g, kg); species diversity (Shannon Wiener Index); % cover of habitat; area of habitat (ha); gene pool diversity; biotope matrix; AMBI (marine biotic index); phytoplankton index.
Coastal and sea space	Area of surface (ha); volume (m^3); tidal range (m); depth (m); bathymetry; topography.
Sea water	Depth (m); volume (m^3); pH; salinity; turbidity (mg/l), temperature (C).
Substratum	Area (ha) and depth (m) by type (mud, sand, gravel, etc.).

Marine ecosystem: Processes	**Indicators (examples of units)**
Production	Community production (kcal); Net productivity by species (kcal/ha/yr); P: B (productivity: biomass) ratios.
Decomposition	Amount and number of decomposers (n/ha); Decomposition rate (kg/ha/yr).
Food web dynamics	Changes over time in community composition (abundance (no.); biomass (g, kg); species diversity (diversity indices)); population dynamics (age classes, male: female ratios).
Ecological interactions (inter-and intraspecific)	Competition for food and space; resilience and resistance (e.g., number of predators and proportion of adults and juveniles, survival rate etc.,)
Hydrological processes	Current speed (m/s) and direction; wave height; changes in temperature ('C); changes in salinity; changes in turbidity (mg/I); NAO (North-Atlantic Oscillation) cycles.
Geological processes	Sediment accumulation rates; slopes; seabed form; channel depths; erosion-deposition cycles.
Evolutionary process	Changes in genetic diversity; mutation rates; influx/efflux of species (no.).

Intermediate ecosystem services: Supporting services	**Indicators (examples of units)**
Primary production	Quantity of primary production (g C per unit area/volume); Quality of primary production (e.g. efficiency of converting sunlight to carbon).
Larval and gamete supply	Quantity of larvae/gametes supplied to a particular location (number per m?"); Quality of larvae/gametes supplied to a particular location (% affected by disease; mortality rates); link to hydrological processes.
Nutrient cycling	Changes (output of the system less input to the system) in the amount of nitrates, phosphates, silica (g per unit area/volume); Denitrification (kg N/ha/yr).
Water cycling	Changes (output of the system less input to the system) in the amount of water (m^3).
Formation of species habitat	Change in area of habitat (per ha); change in quality of habitat; change in number of juveniles; deviation of hydrographic processes.
Formation of physical barriers	Change in amount of natural barriers e.g. salt marsh, reefs, sand dunes, reed beds etc (% cover, ha).
Formation of seascape/landscape	Changes in area by scenic type (ha, % cover, visual range (m, km)).

Intermediate ecosystem services: Regulating services	Indicators (examples of units)
Biological control	Quantity of pest/disease/predator-control species (number); Quality of pest/disease-control species (prevalence).
Natural hazard regulation	Width or area (and volume if applicable) of salt marsh, reed bed, mudflat, sand dunes etc. (m, % cover, ha, m^3) absorbing energy.
Waste breakdown and detoxification	Width or area (and volume if applicable) of salt marsh, density or canopy of coastal forests, reed bed, mudflat, sand dunes etc. (m, % cover, ha, m3) absorbing energy.
Carbon sequestration	Amount of carbon sequestered (tons of CO_2 per m^2 or m^3); Assimilative and recycling capacity, net carbon storage (tonstons per hectare per year).

Final ecosystem services: Provisioning services	Indicators (examples of units)
Fish and shellfish	Fish and shellfish population size (biomass of fish/shellfish in tons); Quality of the fish, shellfish (age profile; length profile; % affected by disease; mortality rates).
Algae and seaweed	Quantity of seaweed stock (biomass in tons, area of seaweed ha); Quality of seaweed stock (% affected by disease; mortality rates).
Ornamental materials	Quantity of raw material (tons); Quality of raw material (concentration).
Genetic resources	Quantity of species with potential/actual useful genetic raw material (tons); Gene bank composition (e.g. number of species and subspecies); Quality of species with potential/actual useful genetic raw material (tons equivalent if variation in quality)
Water supply	Quantity of water extracted for (e.g.) irrigation, cooling and ballast.

Final ecosystem services: Regulating services	Indicators (examples of units)
Climate regulation	Greenhouse gas balance of coastal and marine ecosystems (g C); Quantity of greenhouse gases fixed and/or emitted; Effect on climate parameters (temperature, rainfall, wind, etc).
Natural hazard protection	Width or area of salt marsh, reed bed, mudflat, sand dunes etc. providing natural hazard protection (m, % cover, ha); sediment stabilization properties; water retention capacity (m^3); (wave) energy dissipation capacity.
Clean water and sediments	Amount of waste that can be recycled or immobilized (tons); Biological oxygen demand (mg O_2/liter/day); Amount of organic matter in water and sediment (mg/l); Amount of heavy metals in water and sediment (mg/I); Amount of bacteria in water and sediments (mg/l); Heavy metal (and other pollutant) content in marine organisms (concentration).

Final ecosystem services: Cultural	Indicators (examples of units)
Seascapes and landscapes	Number of designated sites to be protected areas, designated tourism sites, sacred sites, OECMs, etc.; Number/area of specific seascape and landscape features; % of total natural seascape and landscape.

Goods/benefits: Provisioning services	Indicators (examples of units)
Food (wild, farmed)	Nutrition from seafood consumption (g protein/year or g protein/year/head or per household); captured fish landed for human consumption (landings data at particular times and places in tons); farmed fished production (tons/year).
Fish feed (wild, farmed, bait)	Nutrition from non-human seafood consumption (g protein/year); Fish landed not for human consumption (landings data at particular times and places in tons); Bait landed for angling (tons); Quantity of bait collected by type.
Fertilizer and biofuels	Mineral and other content used (e.g. N concentration in g, tons); Quantity of biomass harvested for energy production.
Ornaments and aquaria	Ornamental use (tons) by type; Number of people/businesses who rely on ornamental artefacts (no.); number of ornaments that are legal and illegal traded in aquaria.
Medicines and blue biotechnology	Contribution to medicines (number of medicines); Total amount of useful substances that-can be extracted (kg/ha); Quantity of specific blue biotechnologies (e.g., biocatalysts).

Goods/benefits: Regulating services	Indicators (examples of units)
Healthy climate	Physical damage avoided through net GHG sequestration and effects on climate parameters; bodily harm avoided (lives saved and injuries not incurred) through net GHG sequestration and effects on climate parameters.
Prevention of coastal erosion	Number of prevented hazards (no./yr); avoided displacement of residents/businesses (number of people, m^2 of buildings); quantity of risk prevention (quantity of assets affected adjusted for risk).
Coastal protection	Amount of man-made infrastructure no longer required; Businesses and people protected from flooding; Number of flood related mortalities; Flooding days per year (combined with rainfall indicator)
Waste burial/removal/ neutralization	Quantity of degradable waste deposited (tons by type); Quantity of non-degradable waste deposited (tons by type); Pollution damage avoided by not disposing degradable and non-degradable waste elsewhere (type and extent); Treatment and engineering works not required (type and capacity); Changes in activity not implemented due to capacity to immobilize waste (quantity and/or other characteristics of activity).

Goods/benefits: Cultural services	Indicators (examples of units)
Tourism and nature watching	Number of participants (no./yr); revenues from natural site/MPAs; Number of facilities (number visitors per facility/yr); Amount of time spent participating (hours/days).
Spiritual and cultural well-being	Sites with cultural heritage/wellbeing (usage rates by people, degree of importance); Sites with spiritual and/or religious significance/wellbeing (number of people who attach significance, degree of significance attached).

Aesthetic benefits	Number and/or area of marine features of given stated appreciation; Length of Heritage Coast (km).
Education	Field trips (number and number of people involved); Classes (numbers and number of people involved); Scientific studies (number of research papers, subscriptions, library borrowing, on-line downloads); Books (number, print run, library usage, e-book downloads); other publications including newspaper articles (circulation including on-line accessing); works of art (number of works, number of people viewing work)

(Modified from Turner et al., 2014)

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Supported by:

Federal Ministry
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Nuclear Safety and Consumer Protection

based on a decision of
the German Bundestag

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