

Thailand State of Environmental Performance Index 2023

Office of Natural Resources and Environmental Policy and Planning

Introduction

Thailand State of Environmental Performance Index is prepared by Strategy and Planning Division, Office of Natural Resources and Environmental Policy and Planning of Ministry of Natural Resources and Environment with the objective to disseminate and create awareness and understanding about the Environmental Performance Index (EPI), ranking results of Environmental Performance Index and the assessment of Environmental Performance Index of Thailand. The report also provides policy recommendations to use as supporting information and guidelines for decision making in the formulation of policies and management plans for the country's natural resources and environment.

Environmental Performance Index (EPI) is an indicator in a subplan aims for the establishment of eco-friendly growth on green economic society, which under the country's Master Plan under the National Strategy- Target 18: Eco-friendly Growth. The EPI goals were set for the year 2023 – 2027, 2028 – 2032, 2033 – 2037 at the score not lower than 55, 60 and 65 respectively. Previously, the report of operation for those indicators was carried out in line with the assessment of Yale University and Columbia University, which published every two years since 2006. The latest biennial report was published in 2022. This report is known as “Environmental Performance Index developed by the cooperation between Yale University and Columbia University (EPI Yale & Columbia)”. However, the Office of Natural Resources and Environmental Policy and Planning creates the “Environmental Performance Index using data from agencies in Thailand (EPI+)” which has the format of calculation and weights in line with the EPI Yale & Columbia but using current data from government agencies in Thailand for the calculation. The office also creates “Environmental Performance Index in the context of Thailand (EPI Thailand)” as selected indicators having calculation formats consistent with Thailand's context and relating to the country's policies and planning. These indexes are used as information to report and assess the situation for clarity of targets at national subplan level.

The Office of Natural Resources and Environmental Policy and Planning sincerely hopes that this report of Thailand State of Environmental Performance Index will be beneficial for various sectors to bring joint efforts driving the operations to uplift the score of Thailand's Environmental Performance Index, that will result in raising the score of the assessment at global level. This will also lead to the sustainability of the country's natural resources and environment as well as being the source of information for policy makers in government agencies, private sectors, educational institutions, civil society and the general public in the future.

October 2023

Environmental Performance Index

The Environmental Performance Index (EPI) is an indicator used to assess the situation and actions taken to solve environmental issues. It is an international ranking system that provides environmental rankings to countries around the world, developed by Yale University and Columbia University (Yale Centre for Environmental Law & Policy/Columbia Centre for International Earth Science Information Network). The aim is to standardize each country's performance on environmental actions based on academic principles under empirical supporting data. EPI is characterized as an index value that places countries on a 0 - 100 scale from worst to best performance. An EPI score approaching 100 means good operational performance. Yale University and Columbia University have divided the assessment levels into overall EPI scores, indicating the scores of policy objectives, issue categories, and performance indicators.

The Environmental Performance Index is in line with the Sustainable Development Goals (SDGs), including the alignment between the Environmental Performance Index and national plans and policies, namely the Master Plan under National Strategy, the Thirteenth National Economic and Social Development Plan (2023 - 2027) and Environmental Quality Management Plan 2023 - 2027.

The 2022 Environmental Performance Index Assessment report found that Denmark received the highest score out of 180 countries (a score of 77.9), Japan received the highest score in the Asia-Pacific group (a score of 57.2), Singapore received the highest score in the ASEAN group (a score of 50.9). Thailand received a score of 38.1, ranked 108th out of 180 countries, 8th in the Asia-Pacific group, and 3rd in the ASEAN group (The ranking improved from the results of the assessment in 2018 and 2020, which ranked 5th and 4th in the ASEAN group, respectively.).

According to a study of the Environmental Performance Index developed by Yale University and Columbia University published in 2022, EPI comprises of 11 issue categories, 40 performance indicators within 3 policy objectives: Environmental Health, Climate Change, and Ecosystem Vitality. Based on the study and analysis of the 2022 Environmental Performance Index using data from agencies in Thailand (EPI+), the score of EPI+ is 49.6, with the scores for all 3 policy objectives of 49.9, 32.9 and 63.5, respectively. The draft Environmental Performance Index in the context of Thailand (EPI Thailand) comprises of 3 policy objectives, 11 issue categories and 40 performance indicators. There are 25 agencies that have provided data in the assessment. The score of EPI Thailand is 78.0, with the scores for all 3 policy objectives of 62.1, 89.5 and 75.2, respectively.

Driving Thailand's Environmental Performance Index is executed through the Thailand's Environmental Performance Index Management Plan. It is a guideline for relevant agencies to collect and compile data for use in assessing the Thailand's Environmental Performance Index for both EPI+ and EPI Thailand. This is to ensure that the preparation and reporting of Thailand's Environmental Performance Index are continually efficient and sustainable. The Office of Natural Resources and Environmental Policy and Planning is the focal point agency for collecting data from the Environmental Performance Index database and disseminating to the public through seminars on the preparation of the report of Thailand State of Environmental Performance Index.

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Chapter 1 Environmental Performance Index (EPI)

Chapter 1 provides general information about the Environmental Performance Index, interpretation of Environmental Performance Index, its significance to the management of the country's natural resources and environment as well as the development of data collection and evaluation of Environmental Performance Index scores.

1.1 Definition and Significance of Environmental Performance Index

The Environmental Performance Index (EPI) is an indicator used to assess the situation and actions taken to solve environmental issues. It is an international ranking system that provides environmental rankings to countries around the world, developed by Yale University and Columbia University (Yale Centre for Environmental Law & Policy/ Columbia Centre for International Earth Science Information Network). The aim is to standardize each country's performance on environmental actions based on academic principles under evidence-based supporting data. The assessment is similar to indicators of the Gross Domestic Product (GDP) and Gross National Product (GNP).

EPI is characterized as an index value on a 0 - 100 scale. The ranking will consider from proximity to the target and index value, ranking each country against the best and worst performing targets. An EPI score approaching 100 means good operational performance. Yale University and Columbia University have divided the assessment levels into overall EPI scores, indicating the scores of Policy objectives, Issue categories, and Indicators.

Yale University and Columbia University have published the EPI biennially. The first report was published in 2006. In each round of preparation of Environmental Performance Index, there are changes in components, weights and methods of assessment in line with interesting environmental situations in that particular period of time.

Results of EPI assessment are greatly beneficial for executives charting policies and management plans of natural resources and environment. They will know the status and direction of environmental management, that can be used as tools to support actions and decision making on policies and in-depth plans. The EPI assessment also assists in prioritizing decisions on investments or resources management in areas that should be focus and worth the investments. Moreover, positive relationship between the EPI assessment and Gross Domestic Product (GDP) (Figure 1) also reflects the importance of efficiency of operation on environmental management that will help elevate and promote the country's sustainability.

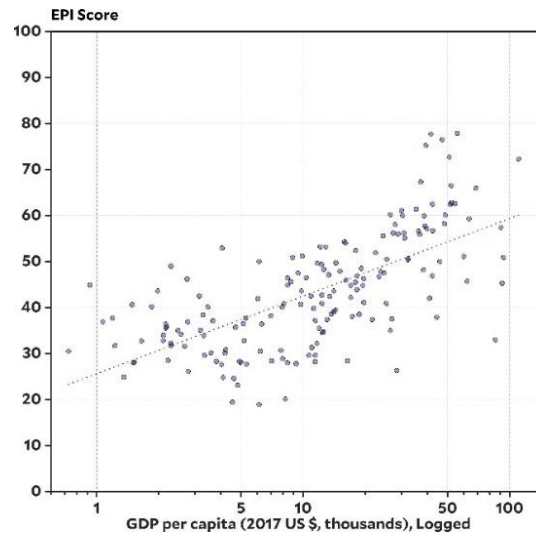


Figure 1: Relationship of assessment results of EPI and GDP in latest published EPI report (2022)
Source: Wolf et al. (2022)

1.2 Report and Dissemination of Environmental Performance Index Data

The development of data collection, scoring of Environmental Performance Index and country ranking has evolved along the time. A pilot project on assessment of Environmental Performance Index commenced in 2006 by applying a method of data collection in a certain period to use in score calculation. In 2006, Thailand received the average score of 66.8, ranked 61st out of 133 countries. In 2008, the score was at 79.2, ranked 53rd out of 149 countries and the score was at 62.2 in 2010, ranked 67th out of 163 countries.

In 2012, there were changes in calculation method and data used in ranking of Environmental Performance Index in the pattern of the Pilot Trend Environmental Performance Index (Trend EPI) to demonstrate changing trend of each country, whether they had policies that could lead to development of environmental performance in the right direction. Therefore, score or rank in this year was incomparable to indexes between 2006 and 2010. Thailand's Trend EPI was at 10th, ranked 34th out of 132 countries.

Later in 2014, there was an attempt to modify calculation method to cover both traditional scoring and trend Environmental Performance Index by collecting information over a period of 10 years for the calculation. Thailand received the average score of 52.83, ranked 78th out of 178 countries. In 2016, the country received the score of 69.54, ranked 91st out of 180 countries; a score of 49.88 in 2018, ranked 121st out of 180 countries and a score of 45.4 in 2020, ranked 78th out of 180 countries.

The most recent report was published in 2022 with adjustment in assessment groups and weights, which indicated changes in emphasis of environmental issues. Thailand received

the average score of 38.1, ranked 108th out of 180 countries. A summary of Thailand's scores and ranks is shown in Figure 2.

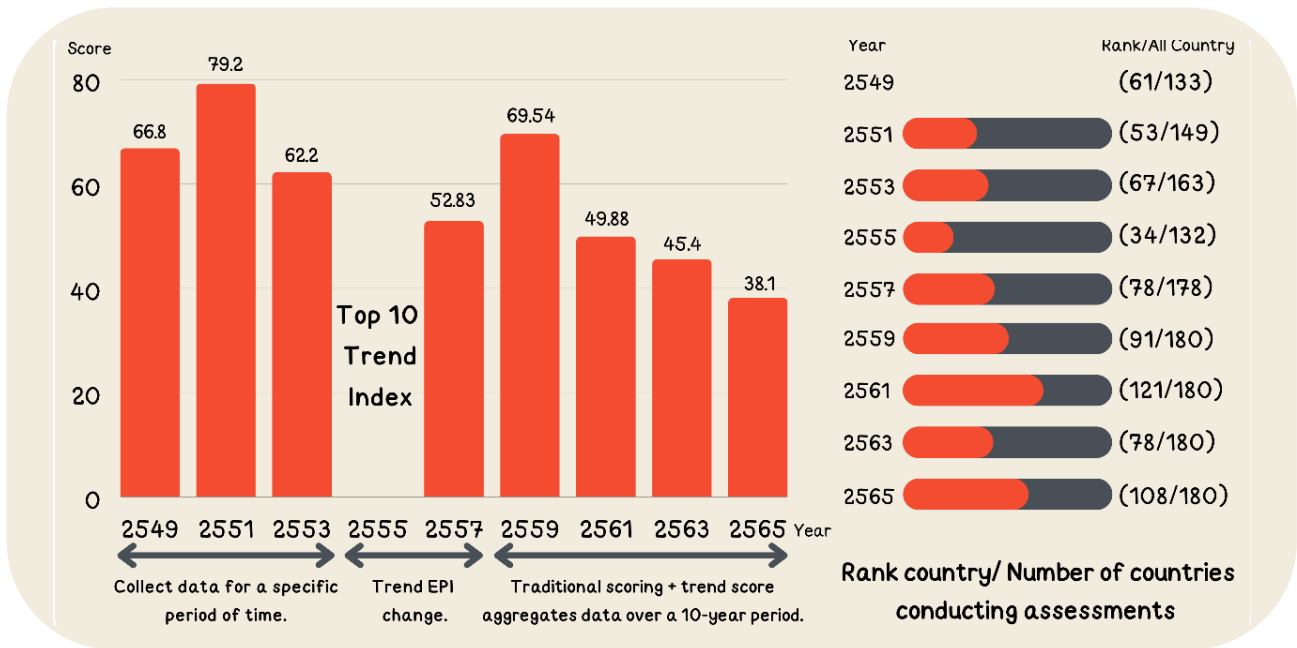


Figure 2: Scores of Thailand Environmental Performance Index from the past to the present

1.3 Assessment of Latest Published Environmental Performance Index Report

In the most recent published assessment results of EPI (2022), there were adjustments in components and weights from previous years. The Policy objectives which earlier assessed in two areas including Environmental Health and Ecosystem Vitality increased to three areas including Environmental Health, Ecosystem Vitality and Climate Change. The report gave more attention to the climate change by elevating it from an Issue category to a Policy objective and gave more weight to this aspect. This reflected the overview of global situations that recognized the significance and urgent need to address the threat from climate change. The appendix A presents details of changes in Policy objectives, Issue categories and Indicators used in assessment of EPI scores between 2006 and 2022.

This most recent EPI report was published in June 2022, comprising 3 Policy Objectives, 11 Issue Categories and 40 Indicators. The **Policy Objective on Environmental Health** had the weight of 20%, comprising Issue Category on Air Quality, Issue Category on Sanitation & Drinking Water, Issue Category on Heavy Metals and Issue Category on Waste Management. **Policy Objective on Climate Change** had the weight of 38%, comprising Issue Category on Climate Change Mitigation and **Policy Objective on Ecosystem Vitality** had the weight of 42%, comprising Issue Category on Ecosystem Services, Issue Category on Fisheries, Issue Category on Acid Rain, Issue Category on Agriculture, Issue Category on Water Resources. The

Framework of Environmental Performance Index assessment which comprising details of Policy Objectives, Issue Categories, Indicators and weights is demonstrated in Figure 3 and Table 1.

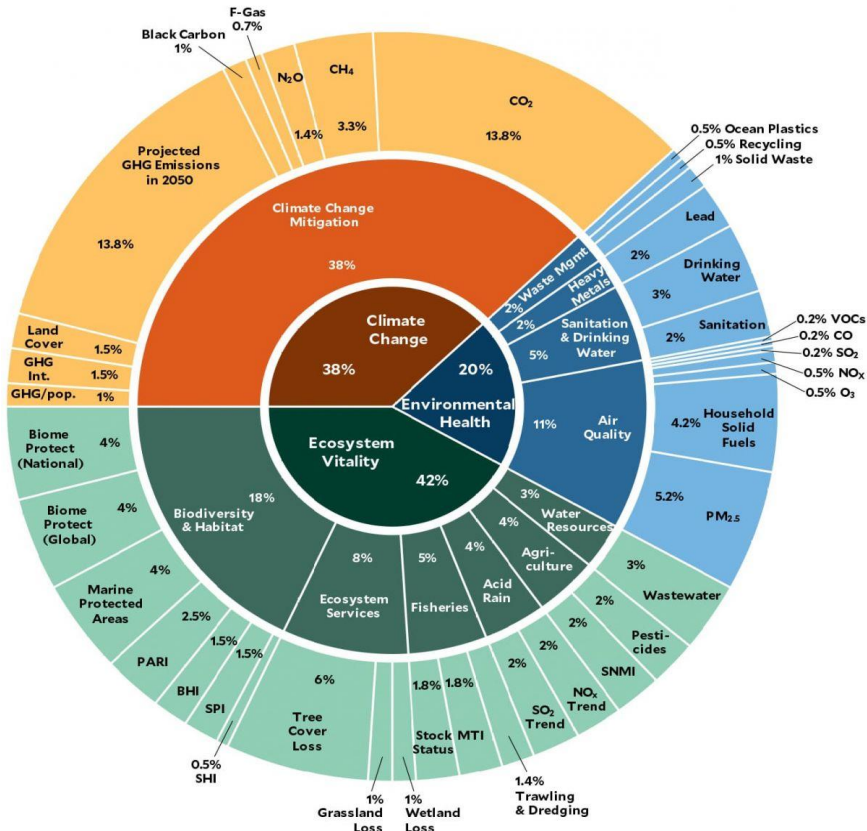













Figure 3: Framework of Environmental Performance Index assessment in 2022

Source: Wolf et al. (2022)

Table 1: Policy objectives, Issue categories, Indicators and weights under the assessment framework of Environmental Performance Index 2022

Assessment framework of Environmental Performance Index 2022		Weights (Percent)
Policy Objective on Environmental Health (EH)		20
	Issue Category on Air Quality	11
	Indicator on PM _{2.5} Exposure (PMD)	5.2
	Indicator on usage of Household Solid Fuels (HAD)	4.2
	Indicator on Ozone Exposure (OZD)	0.5
	Indicator on Nitrogen oxide (NO _x) Exposure (NOE)	0.5
	Indicator on Sulfur dioxide (SO ₂) Exposure (SOE)	0.2
	Indicator on Carbon monoxide (CO) Exposure (COE)	0.2
	Indicator on Volatile Organic Compound (VOC) Exposure (VOE)	0.2
	Issue Category on Sanitation & Drinking Water	5
	Indicator on Unsafe Sanitation (USD)	2
	Indicator on Unsafe Drinking Water (UWD)	3
	Issue Category on Heavy Metals	2
	Indicator on Lead Exposure (PBD)	2
	Issue Category on Waste Management	2
	Indicator on Controlled Solid Waste (MSW)	1
	Indicator on Recycling Rate (REC)	0.5
	Indicator on Ocean Plastic Pollution (OCP)	0.5
Policy Objective on Climate Change (CC)		38
	Issue Category on Climate Change Mitigation	38
	Indicator on Carbon dioxide (CO ₂) Growth Rate (CDA)	13.8
	Indicator on Methane (CH ₄) Growth Rate (CHA)	3.3
	Indicator on Nitrous oxide (N ₂ O) Growth Rate (NDA)	1.4
	Indicator on Fluorinated gas (F-gas) Growth Rate (FGA)	0.7
	Indicator on Black Carbon Growth Rate (BCA)	1
	Indicator on Carbon dioxide (CO ₂) from Land Cover (LCB)	1.5
	Indicator on Greenhouse gas (GHG) per Capita (GHP)	1
	Indicator on Greenhouse gas (GHG) to Gross Domestic Product or GHG Intensity Trend (GIB)	1.5
	Indicator on Projected Greenhouse gas (GHG) Emissions in 2050 (GHN)	13.8

Assessment framework of Environmental Performance Index 2022		Weights (Percent)
Policy Objective on Ecosystem Vitality (EV)		42
 BDH	Issue Category on Biodiversity & Habitat	18
	Indicator on Terrestrial Biome Protection (national) (TBN)	4
	Indicator on Terrestrial Biome Protection (global) (TBG)	4
	Indicator on Marine Protected Areas (MPA)	4
	Indicator on Protected Areas Representativeness Index (PAR)	2.5
	Indicator on Species Protection Index (SPI)	1.5
	Indicator on Species Habitat Index (SHI)	0.5
	Indicator on Biodiversity Habitat Index (BHI)	1.5
 ECS	Issue Category on Ecosystem Services	8
	Indicator on Tree Cover Loss (TCL)	6
	Indicator on Wetland Loss (WTL)	1
	Indicator on Grassland Loss (GRL)	1
 FSH	Issue Category on Fisheries	5
	Indicator on Fish Stock Status (FSS)	1.8
	Indicator on Regional Marine Trophic Index (RMS)	1.8
	Indicator on Fish Caught by Trawling and Dredging (FTD)	1.4
 APE	Issue Category on Acid Rain	4
	Indicator on Sulfur dioxide (SO ₂) Growth Rate (SDA)	2
	Indicator on Nitrogen oxide (NO _x) Growth Rate (NXA)	2
 AGR	Issue Category on Agriculture	4
	Indicator on Sustainable Nitrogen Management Index (SNM)	2
	Indicator on Sustainable Pesticide Use (SPU)	2
 WRS	Issue Category on Water Resources	3
	Indicator on Wastewater Treatment (WWT)	3

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Chapter 2 Environmental Performance Index and Direction of National and Global Development

Chapter 2 provides information about the relationship between Environmental Performance Index and Sustainable Development Goals (SDGs) and the alignment between the Environmental Performance Index and national plans and policies, namely Master Plan under National Strategy, the Thirteenth National Economic and Social Development Plan (2023 - 2027) and the Environmental Quality Management Plan 2023 - 2027.

2.1 Environmental Performance Index and Sustainable Development Goals (SDGs)

Sustainable Development Goals (SDGs) are goals that provide guidelines for global development with conceptual framework that emphasizes the significance of balancing in several dimensions including economic growth, social inclusion and environmental protection in a sustainable manner. There are 17 SDG goals, 169 SDG targets and 247 SDG indicators. The EPI assessment framework has aligned with SDGs for 9 goals, namely Goal 2: Zero Hunger, Goal: 3 Good Health and Well-being, Goal 6: Clean Water and Sanitation, Goal 7: Affordable and Clean Energy, Goal 11: Sustainable Cities and Communities, Goal 12: Responsible Consumption and Production, Goal 13: Climate Action, Goal 14: Life below Water and Goal 15: Life on Land.



Figure 4: Sustainable Development Goals and EPI assessment framework

Goal 2: Zero Hunger, the targets 2.3 and 2.4 pay attention to an increase in agricultural productivity and maintaining soil quality. This is in line with **Issue Category on Agriculture** that has the relationship in maintaining efficiency and effectiveness of cultivation areas, and different types of agricultural products, especially economic crops of the country. It will have direct consequence to the assessment of Issue Category on Agriculture, which has agricultural areas and farm products as representatives for the score assessment of Indicator on Sustainable Nitrogen Management.

Goal 3: Good Health and Well-being, the target 3.9 aims at reducing deaths and sicknesses from hazardous chemicals and air, water and soil pollution and contamination as well as deaths from unsafe water and sanitation and deaths from unintentionally exposure to poisons. This is in line with **Issue Category on Air quality**, **Issue Category on Sanitation & Drinking Water** and **Issue Category on Heavy Metals** that have consequence to risk

assessment on deaths by diseases caused from exposure to pollution and contamination. It will have direct impact to the score of Environmental Performance Index on Environmental Health if there is the application of Disability-adjusted Life Years (DALYs) values as representatives in assessing the scores for indicators such as Issue Category on Air Quality - Indicator on PM_{2.5} Exposure; Issue Category on Sanitation & Drinking Water - Indicator on Unsafe Drinking Water; and Issue Category on Heavy Metals - Indicator on Lead Exposure.

Goal 6: Clean Water and Sanitation, the targets 6.1 and 6.2 mention universal access to safe drinking water and adequate access to sanitation and hygiene including ending of defecation in open environment. This is in line with **Issue Category on Sanitation & Drinking Water** that directly impacts the proportion of households that have access to clean drinking water and proper hygiene. It also influences the scores of indicators measuring the number of households with access to clean drinking water and safe sanitation in the assessment such as Issue Category on Sanitation & Drinking Water – Indicator on Unsafe Drinking Water. For the target 6.3, it aims to improve water quality, reduce pollution, eliminate garbage dumping and minimize releasing of hazardous chemicals and materials, halve the proportion of untreated wastewater and increase recycling and safe reuse in a sustainable way. These will impact the scores of indicators under the **Issue Category on Water Resources** – Indicator on Wastewater Treatment that uses information on proportion or amount of treated wastewater in the calculation. For the target 6.6, it aims to protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. These are in line with the **Issue Category on Ecosystem Services and Issue Category on Biodiversity & Habitat** that will impact the scores of indicators measuring loss of forest areas such as Issue Category on Ecosystem Services – Indicator on Tree Cover Loss and Issue Category on Biodiversity & Habitat – Indicator on Terrestrial Biome Protection-national level. It also affects the score of an indicator measuring information on wetlands such as Issue Category on Ecosystem Services – Indicator on Wetland Loss.

Goal 7: Affordable and Clean Energy, the target 7.1 emphasizes access to reliable modern energy at affordable price with an indicator that pays attention to the proportion of population accessing to electricity and proportion of population mainly depending on fuel and clean technology. This will affect the score of an indicator on **Issue Category on Air Quality** – Indicator on Usage of Household Solid Fuels. Solid fuel is the major fuel that causes the most air pollution in households.

Goal 11: Sustainable Cities and Communities, the target 11.6 tries to reduce adverse per capita environmental impact of cities by paying special attention to air quality, management of municipal solid waste and other waste. The measurement relates to waste and fine particulate matter in cities is in line with **Issue Category on Waste Management and Issue Category on Air Quality**. The reduction of municipal waste relates to the amount of collected and managed waste, which affects the scores of indicators that measure the amount

of collected and managed waste by different methods such as Issue Category on Waste Management – Indicator on Controlled Solid Waste. For fine particulate matter, the SDGs will consider the annual average levels of fine particulate matter for both PM₁₀ and PM_{2.5} which have consequence to the scores of indicators measuring the intensity of fine particulate matter as assessment criteria such as Issue Category on Air Quality – Indicator on PM_{2.5} Exposure.

Goal 12: Responsible Consumption and Production, the targets 12.2, 12.3 and 12.5 mention about efficient usage of natural resources, reduction of food waste and food losses and reduction of waste generation through prevention, reduction, recycling and reuse. These are in line with **Issue Category on Waste Management** as it is the reduction of waste at origin, relating to the score of Indicator on Controlled Solid Waste. The target 12.4 focuses on management of chemicals and all wastes under international cooperation frameworks with the attempt to reduce releasing pollution to air, water and soil in order to minimize adverse effects on health and environment. This relates to the control of amount of chemicals usage, particularly pesticides that have direct affect to the score of **Issue Category on Agriculture**.

Goal 13: Climate Action, the target 13.2 aims to integrate climate change measures into national policies, strategies and planning at national level by focusing on measuring overall amount of greenhouse gases emissions each year. This will directly relate to the scores of **Issue Category on Climate Change Mitigation** such as Indicators on emissions of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), greenhouse gas to Gross Domestic Product and greenhouse gas per capita. It also includes **Issue Category on Acid Rain** – Indicators on emissions of sulfur dioxide (SO₂) and nitrogen oxide (NO_x)

Goal 14: Life below Water, the target 14.4 and 14.6 emphasize effective fisheries and ending of overfishing, illegal, unreported and unregulated fishing (IUU) and prohibiting certain form of fishery subsidies that cause over fisheries to restore fish stock. This is in line with **Issue Category on Fisheries** as the quantity of marine animals harvest directly relates to the scores of Indicator on Regional Marine Trophic Index and Indicator on Fish Caught by Trawling and Dredging. The target 14.5 mentions conservation of coastal and marine areas through the measurement of coverage of protected areas in relation to marine areas. The information on the coverage and size of marine protected areas affects the score of **Issue Category on Biodiversity & Habitat** – Indicator on Marine Protected Areas.

Goal 15: Life on Land, the target 15.1 mentions conservation, restoration and sustainable usage of terrestrial and inland freshwater ecosystems by focusing on forests, areas significant to biodiversity both on terrestrial and freshwater protected areas. This is in line with **Issue Category on Biodiversity & Habitat** as it affects the score of Indicator on Terrestrial Biome Protection at national level. It is also in line with **Issue Category on Ecosystem Services** – Indicator on Tree Cover Loss.

2.2 Environmental Performance Index and National Plans

In addition to the Environmental Performance Index being an international indicator, it is also defined as a national indicator under the 2nd level plan, namely Master Plan under National Strategy (2023 - 2037) (revised edition) and the Thirteenth National Economic and Social Development Plan (2023 - 2027). The EPI has been prepared in alignment with indicators under the Environmental Quality Management Plan 2023 – 2027, which is a 3rd level plan or an operational plan and the main integrated plan for the management of the country’s natural resources and environment.

2.2.1 Environmental Performance Index and Master Plan under National Strategy

The 20-year national strategies have been translated into Master Plan under National Strategy which its importance is being used as the direction for development and driving tool for the country to achieve the national strategies. It also functions as guidelines on action plans of government agencies. Master Plan under National Strategy (2023 - 2037) (revised edition) is in line with the context of current situations and is more concrete. It also improves the development direction to better align with the context of the country’s development. The revised Master Plan has 23 issues, 5 of which are related to the Environmental Performance Index, namely Issue 3: Agriculture, Issue 6: Smart City and Space, Issue 13: Thai People Well-being Enhancement, Issue 18: Eco-friendly Growth and Issue 19: Integrated Water Management.

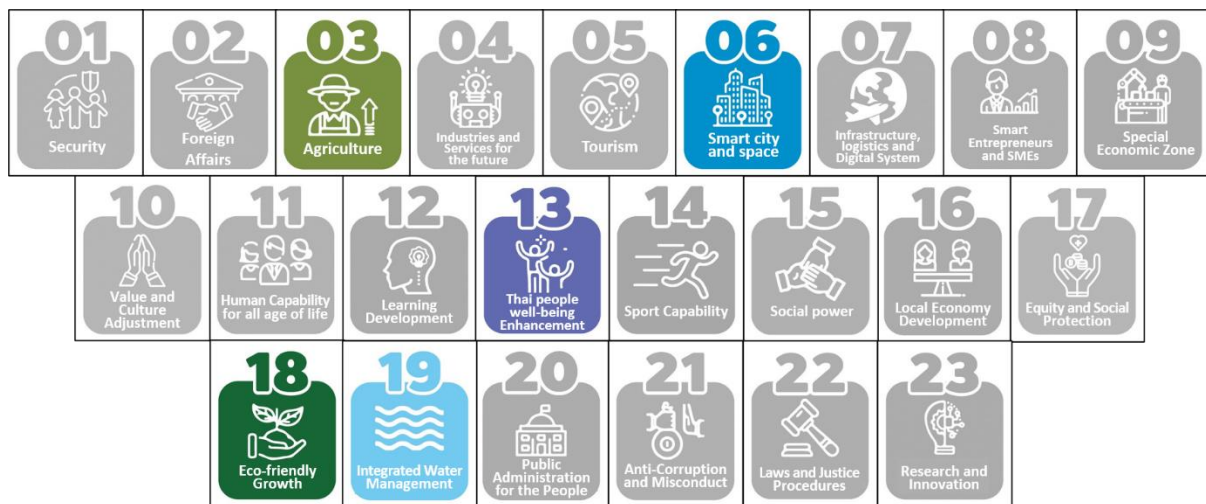


Figure 5: Master Plan under National Strategy in relation to EPI assessment framework

Issue 3: Agriculture, it aims to increase productivity of agricultural sector at the minimum of 1%, 1.2% and 1.3% in the year 2027, 2032 and 2037 respectively. An increase of farm productivity reflects the rise in agricultural output that will affect the score of **Issue Category on Agriculture** – Indicator on Sustainable Nitrogen Management as this indicator uses information on agricultural output in the calculation.

Issue 6: Smart City and Space, it aims for Thailand to elevate the competitiveness, creating the center of social and economic prosperity in all regions across the country in order to distribute social and economic prosperity by assessing from an indicator measuring the growth of provincial Gross Domestic Product (GDP) of economic center cities at 3.6%, 4% and 5% in the year 2027, 2032 and 2037 respectively. The rise in economic growth is consistent with Environmental Performance Index that uses GDP as a component in calculating the indicators. It will affect the scores of **Issue Category on Climate Change Mitigation** including Indicator on Carbon dioxide (CO₂) Growth Rate, Indicator on Methane (CH₄) Growth Rate, Indicator on Nitrous oxide (N₂O) Growth Rate, Indicator on Black Carbon Growth Rate, Indicator on Greenhouse gas (GHG) to Gross Domestic Product. It also relates to **Issue Category on Acid Rain** including Indicator on Sulfur dioxide (SO₂) Growth Rate and Indicator on Nitrogen oxide (NO_x) Growth Rate.

Issue 13: Thai People Well-being Enhancement aims to increase the number of Thai people having better well-being and living conditions. Its indicator is the life expectancy with good health at not lower than 72, 73 and 75 years old in the year of 2027, 2032 and 2037 respectively. Better well-being reflects the decrease in Disability-adjusted Life Years (DALYs). Yale University and Columbia University use DALYs data as representative to assess the scores of Environmental Performance Index for **Issue Category on Air Quality** namely Indicator on PM_{2.5} Exposure, Indicator on Usage of Household Solid Fuels and Indicator on Ozone Exposure; **Issue Category on Sanitation & Drinking Water** including Indicator on Unsafe Sanitation and Indicator on Unsafe Drinking Water; and **Issue Category on Heavy Metals** – Indicator on Lead Exposure.

Issue 18: Eco-friendly Growth, it aims to improve environmental quality of Thailand sustainably. Under the Target 18 of the subplan, the establishment of sustainable growth on green economy intends to bring more sustainability to the country's consumption and production. This target has an indicator which is **Environmental Performance Index scores at the minimum of 55, 60 and 65 in the year 2027, 2032 and 2037 respectively**. There is also the target to increase all types of green spaces such as natural forests, economic forests for utilization, urban and rural green spaces and forests in cities and communities for learning and recreation. Changes in green spaces affect sizes of forests, in line with the scores of Environmental Performance Index using forest areas in the calculation such as **Issue Category on Biodiversity & Habitat** – Indicator on Terrestrial Biome Protection – national level; **Issue Category on Ecosystem Services** – Indicator on Tree Cover Loss. The master subplan on establishment of sustainable growth on marine-based economy sets target for an increase of fertility of marine ecosystem, which reflects the population of marine animals and the diversity of marine animals. This will affect the score of the Environmental Performance Index using the population of marine animals in the calculation such as **Issue Category on Biodiversity & Habitat**. The master subplan on establishment of sustainable growth on climate-friendly society with the target to reduce the country's greenhouse gas emissions affects the Environmental Performance Index that uses data on greenhouse gas emissions or growth in


greenhouse gas emissions in the calculation such as **Issue Category on Climate Change Mitigation** including Indicator on Carbon dioxide (CO₂) Growth Rate, Indicator on Methane (CH₄) Growth Rate, Indicator on Nitrous oxide (N₂O) Growth Rate, Indicator on Greenhouse gas (GHG) per Capita, Indicator on Greenhouse gas (GHG) to Gross Domestic Product; **Issue Category on Acid Rain** including Indicator on Sulfur dioxide (SO₂) Growth Rate and Nitrogen oxide (NO_x) Growth Rate. The subplan on management of pollution, that has an impact on environment and chemicals in entire agricultural sector and be on par with international standards, pays attention to water quality, air quality and noises, management of municipal solid waste, infectious waste and hazardous waste, agricultural chemicals and industrial waste. These are in line with Environmental Performance Index on **Issue Category on Water Resources** – Indicator on Wastewater Treatment; **Issue Category on Air Quality** including Indicator on PM_{2.5} Exposure and Indicator on Ozone Exposure; and **Issue Category on Waste Management** including Indicator on Controlled Solid Waste and Indicator on Municipal Waste Recycling Rate.

Issue 19: Integrated Water Management aims to increase the national water security with indicator scores on national water security at not lower than 70, 75 and 80 in the year 2027, 2032 and 2037 respectively. This is in line with the score of Environmental Performance Index on **Issue Category on Water Resources** – Indicator on Wastewater Treatment.

2.2.2 Environmental Performance Index and the Thirteenth National Economic and Social Development Plan (2023 - 2027)

The Thirteenth National Economic and Social Development Plan (2023 - 2027) is one of essential mechanisms in transforming national strategies into actions and being used as a framework for preparation of 3rd level plans to ensure that the operations of relevant development partners can support the achievement of targets under the national strategies. It sets the development direction to transform the country into “Progressive Society with Sustainable Value-Creating Economy” through 5 main development targets that transform into 13 development milestones.


Development target relates to Environmental Performance Index is target 4 aims to transform production and consumption to the sustainability, using indicator on reduction of overall emissions of greenhouse gas (cover energy/ transportation and logistics/ industrial process/ waste management) by at least 20% when compared to the emissions of greenhouse gas in normal situation. This is in line with **Issue Category on Climate Change Mitigation** including Indicator on Carbon dioxide (CO₂) Growth Rate, Indicator on Methane (CH₄) Growth Rate, Indicator on Nitrous oxide (N₂O) Growth Rate, Indicator on Greenhouse gas (GHG) to Gross Domestic Product and Indicator on Greenhouse gas (GHG) per Capita.

Milestone relates to Environmental Performance Index is Milestone 10,  that aims for Thailand is a circular economy and low-carbon society through target 2: To sustainably conserve, rehabilitate and utilize natural resources, Indicator 2.1 aims to **improve the score**


of Environmental Performance Index for Thailand to rank as a top 3 in ASEAN group, having the score of not lower than 55 in 2027. Indicator 2.2 aims to increase forest areas with the target to have natural forests at 33% and economic forests for utilization at 12% of total areas of the country within 2027. The addition of forest areas affects the scores of Environmental Performance Index that uses forest sizes in the calculation such as **Issue Category on Biodiversity & Habitat** – Indicator on Terrestrial Biome Protection-national level and **Issue Category on Ecosystem Services** – Indicator on Tree Cover Loss. target 3: To establish a low-carbon sustainable society, Indicator 3.1 aims to increase proportion of renewable energy usage to final energy consumption to at least 24% within 2027. An increase of proportion of renewable energy usage will bring changes in the amount of CO₂ emissions that affect Environmental Performance Index that uses data on CO₂ growth rate in the calculation such as **Issue Category on Climate Change Mitigation** including Indicator on Carbon dioxide (CO₂) Growth Rate, Indicator on Methane (CH₄) Growth Rate, Indicator on Nitrous oxide (N₂O) Growth Rate, Indicator on Greenhouse gas (GHG) to Gross Domestic Product and Indicator on Greenhouse gas (GHG) per Capita. At the same time, renewable energy consumption affects the amount of fossil fuel usage which related to **Issue Category on Acid Rain** - Indicator on Sulfur dioxide (SO₂) Growth Rate. Indicator 3.2 aims to increase waste recycling rate by having the nation's waste recycling rate of at least 40% of the amount of recyclable waste within 2027 and Indicator 3.3 aims to reduce the amount of municipal waste per capita in 2027 by 10% from 2017. The change in amount of municipal waste affects the scores of **Issue Category on Waste Management** including Indicator on Controlled Solid Waste and Indicator on Municipal Waste Recycling Rate.


2.2.3 Environmental Performance Index and Environmental Quality Management Plan 2023 – 2027


Environmental Quality Management Plan 2023 - 2027 is an operational framework on natural resources and environment for development partners to drive the operations that will result in achievement of national strategy's goals. This is in particular Goal 5 that aims to establish the growth on quality of life that friendly to the environment. It comprises 5 strategies, 13 sub-strategies, 32 indicators. Its alignment with the Environmental Performance Index is as follows.


Strategy 1:  Management of terrestrial natural resources and biodiversity for growth and fairness based on the balance of natural resource base. Indicator 1.1 aims for the national land area is composed of 45% green areas designated as forests, with 33% being natural forest areas and 12% being economical plantation forest areas. This relates to **Issue Category on Biodiversity & Habitat** – Indicator on Terrestrial Biome Protection (national); and **Issue Category on Ecosystem Services** – Indicator on Tree Cover Loss. Indicator 1.3 measures the total area of land use changes in unsuitable areas under the Agricultural Area

Management Project (Zoning by Agri-Map), which is in line with **Issue Category on Agriculture** – Indicator on Sustainable Nitrogen Management and Indicator on Pesticide Use. This is because the amount of agricultural land of each crop will relate to the amount of usage of nitrogen fertilizer and pesticide.

Strategy 2:  Conservation and restoration of marine ecosystems for the sustainable development of marine resource utilization potential. Indicator 2.1 aims to increase marine and coastal protected areas which directly affect the **Issue Category on Biodiversity & Habitat** – Indicator on Marine Protected Area. Indicator 2.5 aims to manage at least 250 tons of marine debris per annum. Such management of marine debris affects the amount of waste released into the water and relates to **Issue Category on Waste Management** – Indicator on Ocean Plastic Pollution.

Strategy 3:  Management to promote a climate-friendly society. Indicator 3.1 aims to reduce the amount of greenhouse gas emission by at least 21% from business-as-usual. The reduction in greenhouse gas emissions directly affects the scores of **Issue Category on Climate Change Mitigation** including Indicator on Carbon dioxide (CO₂) Growth Rate, Indicator on Methane (CH₄) Growth Rate, Indicator on Nitrous oxide (N₂O) Growth Rate, Indicator on Greenhouse gas (GHG) to Gross Domestic Product and Indicator on Greenhouse gas (GHG) per Capita. Indicator 3.2 aims to increase the proportion of renewable energy usage to final energy consumption. Renewable energy consumption affects the amount of fossil fuel usage which affects **Issue Category on Acid Rain** - Indicator on Sulfur dioxide (SO₂) Growth Rate

Strategy 4:  Managing pollution that impacts the entire ecosystem and urban environment. Indicator 4.1 aims to ensure quality of surface water in good condition at 85% and marine water sources in good condition at 89%, which relates to **Issue Category on Water Resources** – Indicator on Wastewater Treatment. Indicator 4.2 aims to have areas with better air quality at 80%, affects the scores of **Issue Category on Air Quality** – Indicator on PM_{2.5} Exposure and Indicator on Ozone Exposure because the intensity of fine particulate matter (PM_{2.5}) and ozone affects the exposure. Indicator 4.4 aims for 80% of municipal solid waste treated properly. This is in line with **Issue Category on Waste Management** – Indicator on Controlled Solid Waste and Indicator on Municipal Waste Recycling Rate.

Strategy 5:  Paradigm shift for efficient natural resource and environmental management. Indicator 5.3 aims to increase the proportion of sustainable agricultural area to the country's overall agricultural area. This affects the scores of **Issue Category on Agriculture** – Indicator on Sustainable Nitrogen Management Index and Indicator on Sustainable Pesticide Use.

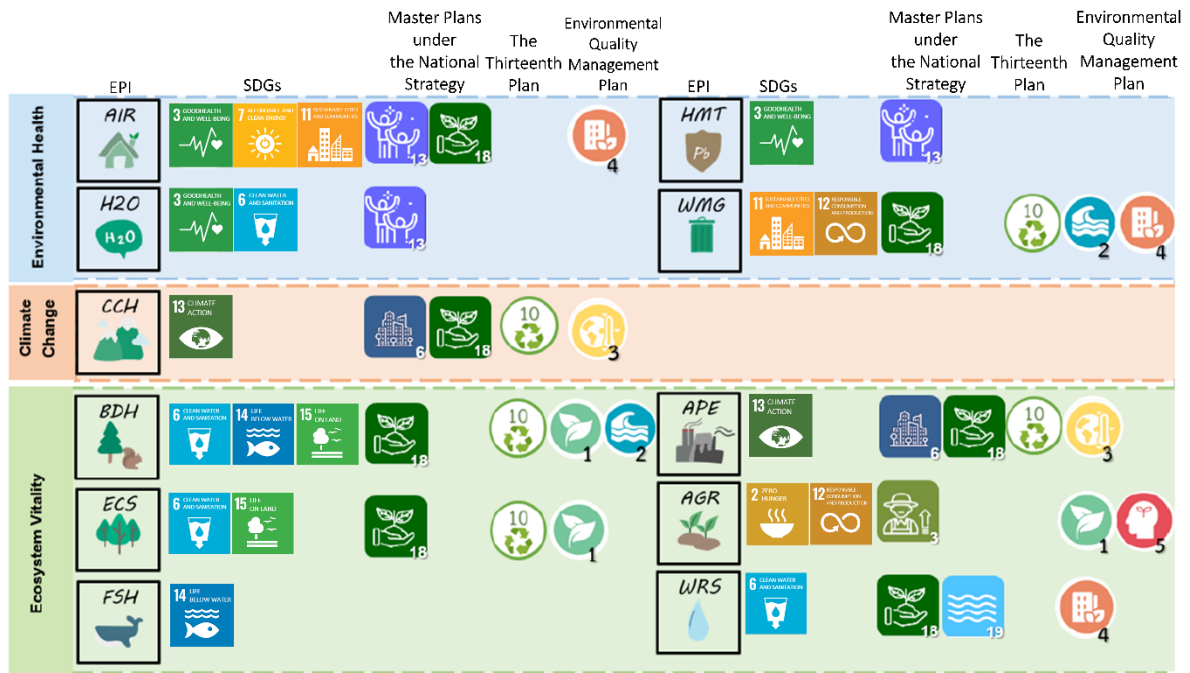


Figure 6: Relationship of Environmental Performance Index with SDGs and Master Plan under National Strategy, Thirteenth National Economic and Social Development Plan (2023 - 2027) and Environmental Quality Management Plan 2023 – 2027

Chapter 3 Thailand Environmental Performance Index

Chapter 3 covers operation concepts in the preparation of Environmental Performance Index, frameworks of variables and results of the Environmental Performance Index of Thailand including Environmental Performance Index developed by the cooperation of Yale University and Columbia University (EPI Yale & Columbia), Environmental Performance Index using data from agencies in Thailand (EPI+) and Environmental Performance Index in the context of Thailand (EPI Thailand).

3.1 Operation Concept

Office of Natural Resources and Environmental Policy and Planning envisions the significance of Environmental Performance Index (EPI) by initiating the EPI study under the fiscal budget year 2022 to study about variables, calculation methods, relevant agencies/responsibility in providing data for EPI assessment under 3 frameworks, namely 1) EPI developed by the cooperation between Yale University and Columbia University (EPI Yale & Columbia); 2) EPI using data from agencies in Thailand (EPI+) which has calculation pattern and weights in line with the EPI Yale & Columbia but using current data from government agencies in Thailand in the calculation; and 3) EPI in the context of Thailand (EPI Thailand) which selected indicators having calculation formats consistent with Thailand's context and relating to the country's policies and planning and also in line with the global context. The Office also creates Thailand Environmental Performance Index database in a format that is convenient to import, store, compile and process the EPI scores from template in form of Excel sheets.

The National Environment Board on its 3rd meeting of 2022 on 3 August 2022 had the resolutions as follows. 1) Approved the report of the Environmental Performance Index of Thailand and assigned the Office of the National Economic and Social Development Council to consider applying EPI+ in its report on the achievement of operation under the subplan on the establishment of sustainable growth on green economic society, under Issue 18: Eco-friendly Growth – of Master Plan under National Strategy. 2) Assigned related agencies to input data into the Environmental Performance Index database within May each year. 3) Assigned Ministry of Natural Resources and Environment through the Office of Natural Resources and Environmental Policy and Planning as the focal point agency for collecting data from the Environmental Performance Index database and disseminating to the public every year. The National Environment Board on its 6th meeting of 2022 on 23 December 2022 had a resolution to appoint a Subcommittee for the Management of Thailand Environmental Performance Index to coordinate the operation and support information in the preparation of Thailand

Environmental Performance Index as well as promote and support the execution of related operations.

For the budget year 2023, the Office of Natural Resources and Environmental Policy and Planning received continuous budget for the preparation of the second phase of the Environmental Performance Index. The Office has drafted a framework about EPI variables in the context of Thailand (EPI Thailand) and formulated Thailand Environmental Quality Management Plan as practice guidelines for relevant agencies to collect and compile data for the assessment of Thailand's EPI for both EPI+ and EPI Thailand. This is to drive policies and plans based on information from relevant parties including government agencies, private sector, educational institutions and civil society. Initially, the Office grouped together Indicators under the Environmental Quality Management Plan 2023 - 2027 that affected the score of Thailand's EPI and established the relationship of indicators and driving activities under the value chain of the Environmental Quality Management Plan.

3.2 Framework of Variables and Assessment Results of Thailand Environmental Performance Index

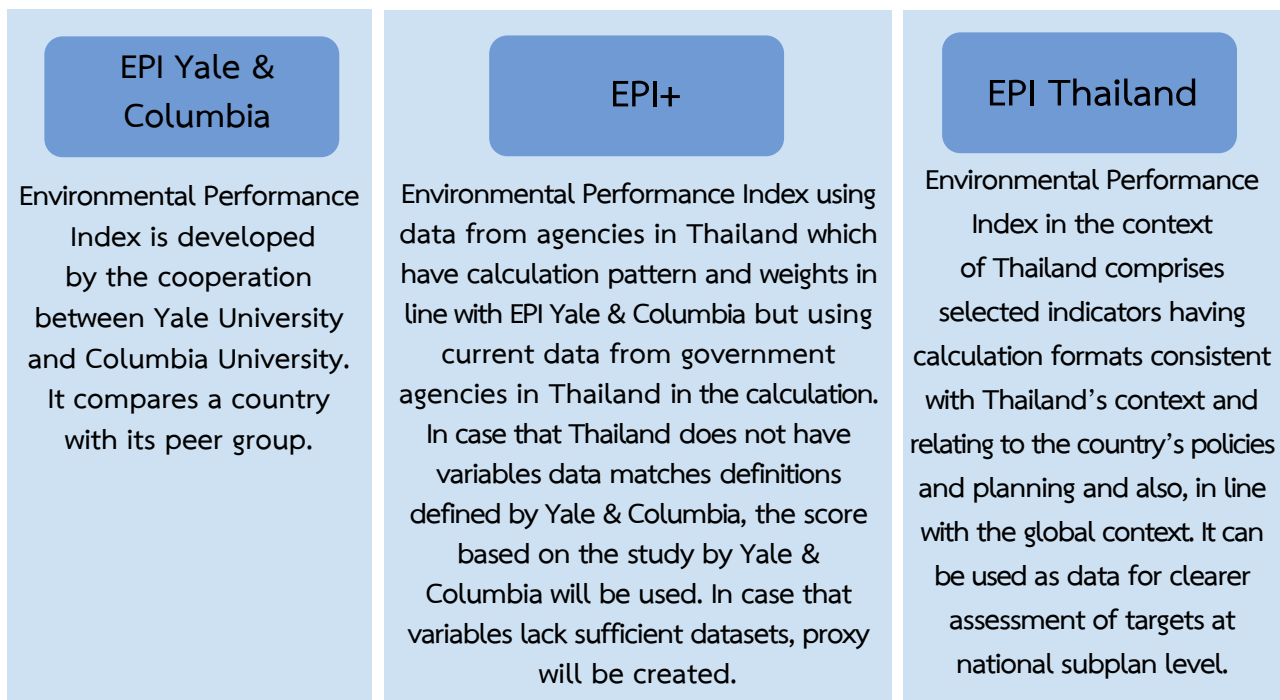


Figure 7: Definitions of EPI Yale & Columbia/ EPI+/ EPI Thailand

3.2.1 Environmental Performance Index Using Data from Agencies in Thailand or EPI+

Published Environmental Performance Index 2020 or **EPI Yale & Columbia 2020** comprised of 11 Issue Categories and 32 Indicators, covering Policy Objective on Environmental Health that emphasized the significance of air quality, sanitation & drinking

water, heavy metals and waste management and Policy Objective on Ecosystem Vitality that focused on biodiversity & habitat, ecosystem services, fisheries, climate change, pollution emissions, agriculture and water resources. The assessment result in 2020, the EPI Yale & Columbia 2020 score was at 54.5, ranked 78th out of 180 countries. **The score of EPI+ was at 57.9.**

Published Environmental Performance Index 2022 or **EPI Yale & Columbia 2022 comprised of 11 Issue Categories and 40 Indicators**, covering Policy Objective on Environmental Health that emphasized the significance of air quality, sanitation & drinking water, heavy metals and waste management; Policy Objective on Climate Change that emphasized the climate change mitigation; and Policy Objective on Ecosystem Vitality that focused on biodiversity & habitat, ecosystem services, fisheries, acid rain, agriculture and water resources. The indicators, definitions, data usage, weights and EPI operational benchmarks (Best – Worst) of EPI+ are shown in Table 2. For the assessment result in 2022, the EPI Yale & Columbia 2022 score was at 38.1, ranked 108th out of 180 countries. **The score of EPI+ was at 49.6.**

Table 2: Indicators, definitions, using data, weights and EPI operational benchmarks (Best – Worst) of EPI+ in 2022

Using data	Data sources/ agencies	Data Period	Data year	Weights (wt.)	Performance Best-Worst
Indicator on PM_{2.5} Exposure					
<i>Definition: Indicator on PM_{2.5} Exposure measures from the number of age-standardized disability-adjusted life-years lost per 100,000 persons due to the exposure to PM_{2.5}.</i>					
DALYs	Institute for Health Metrics and Evaluation (IHME)	1 year	2019	5.2	4.7087 7.9045
Implementation: Use DALYs data in line with assessment direction of Yale University and Columbia University					
Indicator on usage of Household Solid Fuels					
<i>Definition: Indicator on usage of Household Solid Fuels measures from the number of age-standardized disability-adjusted life-years lost per 100,000 persons due to exposure to household air pollution from the use of household solid fuels.</i>					
DALYs	IHME	1 year	2019	4.2	-0.2420 9.2909
Implementation: Use DALYs data in line with assessment direction of Yale University and Columbia University					
Indicator on Ozone Exposure					
<i>Definition: Indicator on Ozone Exposure measures from the number of age-standardized disability-adjusted life-years lost per 100,000 persons due to the exposure to ozone.</i>					
DALYs	IHME	1 year	2019	0.5	0.1084 5.5447
Implementation: Use DALYs data in line with assessment direction of Yale University and Columbia University					

Indicator on Nitrogen oxide (NO _x) Exposure					
<i>Definition: Indicator on Nitrous oxide (NO_x) Exposure measures from the population-weighted annual average concentration of the air pollutant.</i>					
NO _x concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	0.5	-9.1728
Air quality standard in general atmosphere					-3.1919
Population in districts of measurement station locations	Department of Provincial Administration				
Implementation: Use data from government agencies in Thailand					
Indicator on Sulfur dioxide (SO ₂) Exposure					
<i>Definition: Indicator on Sulfur dioxide (SO₂) Exposure measures from the population-weighted annual average concentration of the air pollutant.</i>					
SO ₂ concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	0.2	- 8.1853
Air quality standard in general atmosphere					-2.7703
Population in districts of measurement station locations	Department of Provincial Administration				
Implementation: Use data from government agencies in Thailand					
Indicator on Carbon monoxide (CO) Exposure					
<i>Definition: Indicator on Carbon monoxide (CO) Exposure measures from the population-weighted annual average concentration of the air pollutant.</i>					
CO concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	0.2	-2.7730
Air quality standard in general atmosphere					-0.7553
Population in districts of measurement station locations	Department of Provincial Administration				
Implementation: Use data from government agencies in Thailand					
Indicator on Volatile Organic Compounds (VOCs) Exposure					
<i>Definition: Indicator on Volatile Organic Compounds (VOCs) Exposure measures from the population-weighted annual average concentration of the air pollutant.</i>					
VOCs concentration (ppm)	EAC4	1 year	2019	0.2	-7.1696
					-2.3450
Implementation: Use data of EAC4 in line with assessment direction of Yale University and Columbia University.					

Indicator on Unsafe Sanitation					
<i>Definition: Indicator on Unsafe Sanitation measures from the number of age-standardized disability-adjusted life-years lost per 100,000 persons due to the exposure to unsafe sanitation.</i>					
DALYs	International Health	1 year	2019	2	0.4742
	Policy Program				8.3989
Implementation: Use Thailand's DALYs data provided by International Health Policy Program					
Indicator on Unsafe Drinking Water					
<i>Definition: Indicator on Unsafe Drinking Water measures from the number of age-standardized disability-adjusted life-years lost per 100,000 persons due to access to unsafe drinking water.</i>					
DALYs	International Health	1 year	2019	3	0.8722
	Policy Program				8.6896
Implementation: Use Thailand's DALYs data provided by International Health Policy Program					
Indicator on Lead Exposure					
<i>Definition: Indicator on Lead Exposure measures from the number of age-standardized disability-adjusted life-years lost per 100,000 persons due to lead contamination in the environment.</i>					
DALYs	IHME	1 year	2019	2	3.1070
					7.2247
Implementation: Use DALYs data in line with assessment direction of Yale University and Columbia University					
Indicator on Controlled Solid Waste					
<i>Definition: Indicator on Controlled Solid Waste means the proportion of household and commercial waste generated in a country that is collected and treated in a manner that controls environmental risks.</i>					
Amount of solid waste	Pollution Control	1 year	2022	1	1.0
	Department				0.0
Implementation: Use data from government agencies in Thailand					
Indicator on Recycling Rate					
<i>Definition: Indicator on Recycling Rate means the proportion of post-consumer recyclable materials (glass, plastic, paper, and metal) that is recycled.</i>					
Components of solid waste separated at landfill sites	Pollution Control	1 year	2022	0.5	1.0
	Department				0.0
Proportion of recycled waste	Chen et al., 2020	1 year	2020		
Implementation: Use data from government agencies in Thailand					

Indicator on Ocean Plastic Pollution					
<i>Definition: Indicator on Ocean Plastic Pollution means the total mass of post-consumer plastics entering the ocean each year.</i>					
Amount of plastic waste (tons)	Pollution Control Department	1 year	2022	0.5	-12.3114
Emission of plastic waste released into the oceans	Meijer et al., 2021				-0.5213
Implementation: Use data from government agencies in Thailand					
Indicator on Carbon dioxide (CO ₂) Growth Rate					
<i>Definition: Indicator on Carbon dioxide (CH₂) Growth Rate means carbon dioxide emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
CO ₂ emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	13.8	-0.0759
Gross Domestic Product (PPP, constant 2017 international\$)	World Bank & IMF				0.0759
Implementation: Use data from government agencies in Thailand					
Indicator on Methane (CH ₄) Growth Rate					
<i>Definition: Indicator on Methane (CH₄) Growth Rate means methane emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
CH ₄ emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	3.3	-0.05
Gross Domestic Product (PPP, constant 2017 international\$)	World Bank & IMF				0.05
Implementation: Use data from government agencies in Thailand					

Indicator on Nitrous oxide (N ₂ O) Growth Rate					
<p><i>Definition: Indicator on Nitrous oxide (N₂O) Growth Rate means nitrous oxide emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i></p>					
N ₂ O emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	1.4	-0.0195 0.0551
Gross Domestic Product (PPP, constant 2017 international\$)	World Bank & IMF				
Implementation: Use data from government agencies in Thailand					
Indicator on Fluorinated gas (F-gas) Growth Rate					
<p><i>Definition: Indicator on Fluorinated gas (F-gas) Growth Rate means fluorinated gas emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not land use, land-use change and forestry. Sources of fluorinated gas considered by Yale University and Columbia University are HFCs, PFCs and SF₆ which released from industrial process and product use.</i></p>					
F-gas emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	0.7	-0.0394 0.2
Implementation: Use data from government agencies in Thailand					
Indicator on Black Carbon Growth Rate					
<p><i>Definition: Indicator on Black Carbon Growth Rate means black carbon emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. Sources of black carbon considered by Yale University and Columbia University are releasing sources from energy and waste sectors.</i></p>					
Fuel quantity of energy sector	Department of Alternative Energy Development and Efficiency	10 years	2010 - 2019	1	-0.0187 0.0515
Emissions from biomass burning from sectors of agriculture, forestry, land use and burning waste in incinerators of the waste sector.	Department of Climate Change and Environment				
Gross Domestic Product (PPP, constant 2017 international\$)	World Bank & IMF				
Implementation: Use data from government agencies in Thailand					

Indicator on Carbon dioxide (CO ₂) from Land Cover					
<p><i>Definition: Indicator on Carbon dioxide (CO₂) from Land Cover means carbon dioxide emission rate generated from change in land utilization over time, caused from tree cover change by considering above-ground and underground biomass and dead wood. Then assess carbon dioxide emission using recommended emission factors from the Guidelines for National Greenhouse Gas Inventories.</i></p>					
CO ₂ emission growth rate from land cover	Department of Climate Change and Environment	10 years	2008 - 2017	1.5	-0.1295 0.2142
Implementation: Use data from government agencies in Thailand					
Indicator on Greenhouse gas (GHG) per Capita					
<p><i>Definition: Indicator on Greenhouse gas (GHG) per Capita means the emission of all greenhouse gases (carbon dioxide, methane, nitrous oxide and fluorinated group) per one person, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i></p>					
Quantity of greenhouse gas emission (excluding LULUCF)	Department of Climate Change and Environment	1 year	2019	1	-6.9128 -3.7592
Population	Department of Provincial Administration				
Implementation: Use data from government agencies in Thailand					
Indicator on Greenhouse gas (GHG) to Gross Domestic Product					
<p><i>Definition: Indicator on Greenhouse gas (GHG) to Gross Domestic Product means the emission of all greenhouse gases (carbon dioxide, methane, nitrous oxide and fluorinated group) to Gross Domestic Product over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i></p>					
GHG emission rate	Department of Climate Change and Environment	10 years	2010 - 2019	1.5	-0.0632 0.0283
Gross Domestic Product (PPP, constant 2017 international\$)	World Bank & IMF				
Implementation: Use data from government agencies in Thailand					
Indicator on Projected Greenhouse gas (GHG) Emissions in 2050					
<p><i>Definition: Indicator on Projected Greenhouse gas (GHG) Emissions in 2050 means the emission of all greenhouse gases in 2050 (carbon dioxide, methane, nitrous oxide and fluorinated group), generated by human</i></p>					

<i>activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
Quantity of greenhouse gas emission (excluding LULUCF)	Department of Climate Change and Environment	10 years	2010 - 2019	13.8	5.4612 13.9194
Implementation: Use data from government agencies in Thailand					
Indicator on Terrestrial Biome Protection (national)					
<i>Definition: Indicator on Terrestrial Biome Protection (national) means the proportion of essential terrestrial biome under the protected area, weighted by the proportion of distribution of each type of terrestrial biome in the country in order to achieve Aichi Biodiversity Targets.</i>					
Forest areas	Royal Forest Department	10 years	2013 - 2022	4	17.0 0.0
Conservation areas	Department of National Park, Wildlife and Plant Conservation				
Implementation: Use data from government agencies in Thailand					
Indicator on Terrestrial Biome Protection (global)					
<i>Definition: Indicator on Terrestrial Biome Protection (global) means the proportion of essential terrestrial biome under the protected area, weighted by the proportion of distribution of each type of terrestrial biome in the world in order to achieve Aichi Biodiversity Targets.</i>					
Forest areas	Royal Forest Department	10 years	2013 - 2022	4	17.0 0.0
Conservation areas	Department of National Park, Wildlife and Plant Conservation				
Global forest areas	World Database on Protected Areas (WDPA)				
Implementation: Use data from government agencies in Thailand					
Indicator on Marine Protected Areas					
<i>Definition: Indicator on Marine Protected Areas means the proportion of marine protected areas to overall Thai waters, which demonstrate the protection of marine ecosystem in order to achieve Aichi Biodiversity Targets.</i>					
Marine protected areas and Thai waters	Department of Marine and Coastal Resources	1 year	2022	4	10.0 0.0
Implementation: Use data from government agencies in Thailand					
Indicator on Protected Areas Representativeness Index					
<i>Definition: Indicator on Protected Areas Representativeness Index means how well protected areas represent biodiversity of a country. If protected areas cover a large portion of a country's habitats of various living species, they (biodiversity) have been protected under the coverage of those protected areas.</i>					

Environmental factors and locations of living species	NatureServe	-*	2000 - 2020	2.5	0.31 0.0308
Protected areas	World Database on Protected Areas (WDPA)				
Implementation: Use data of NatureServe and WDPA in line with assessment direction of Yale University and Columbia University					
Indicator on Species Protection Index					
<i>Definition: Indicator on Species Protection Index means how well protected terrestrial areas cover habitats of species ranges of vertebrates, invertebrates and plant varieties.</i>					
Distribution of living species	Map of Life	- *	1980 - 2021	1.5	100 0
Protected areas	World Database on Protected Areas (WDPA)				
Implementation: Use data of Map of Life and WDPA in line with assessment direction of Yale University and Columbia University					
Indicator on Species Habitat Index					
<i>Definition: Indicator on Species Habitat Index means the proportion of appropriate habitats for living species in natural conditions, comparing to a baseline set in the year 2001.</i>					
Change of area sizes, quality of habitats of living species and data on distribution of living species	Map of Life	- *	2001 - 2014	0.5	100 93.3115
Implementation: Use data of Map of Life in line with assessment direction of Yale University and Columbia University					
Indicator on Biodiversity Habitat Index					
<i>Definition: Indicator on Biodiversity Habitat Index estimates the effects of habitat loss, degradation, and fragmentation of habitat to the terrestrial biodiversity.</i>					
Habitat and distribution of living species	NatureServe	- *	2020	1.5	1 0
Implementation: Use data of NatureServe in line with assessment direction of Yale University and Columbia University					
Indicator on Tree Cover Loss					
<i>Definition: Indicator on Tree Cover Loss means the measurement of the average annual loss in forest areas over the past 5 years, divided by the total extent of forest areas in the base year.</i>					
Forest areas	Royal Forest Department	5 years	2017 - 2022	6	-13.845 -3.9194
Implementation: Use data from government agencies in Thailand					
Indicator on Wetland Loss					
<i>Definition: Indicator on Wetland Loss means the measurement of the average annual loss in wetland areas over the past 5 years, divided by the total extent of wetland areas in 1992.</i>					

Wetland areas	Land Development Department and Department of Water Resources	5 years	2017 - 2022	1	-12.911 -2.7078
Implementation: Use data from government agencies in Thailand					
Indicator on Grassland Loss					
<i>Definition: Indicator on Grassland Loss means the measurement of the average annual loss in grassland areas over the past 5 years, divided by the total extent of grassland areas in 1992.</i>					
Grassland area	Land Development Department	6 years	2015 - 2021	1	-12.323 -3.9194
Implementation: Use data from government agencies in Thailand					
Indicator on Fish Stock Status					
<i>Definition: Indicator on Fish Stock Status means the percentage of a country's total catches that come from overexploited or collapsed stocks, considering all fish stocks within the country's Exclusive Economic Zone (EEZ). This is under the concept that a country should reduce or limit fish catches come from stocks that are overexploited or collapsed.</i>					
Marine animals catch	Department of Fisheries	10 years	2013 - 2022	1.8	-4.6040 -0.2516
Implementation: Use data from government agencies in Thailand					
Indicator on Regional Marine Trophic Index					
<i>Definition: Indicator on Regional Marine Trophic Index means that average hierarchical feeding of large ecosystem that used to indicate the entering of "fishing down the food web". The index measures utilization of fish stocks at higher trophic levels and sustainable management of fishery resources.</i>					
Regional Marine Trophic Index (RMTI)	Sea Around Us	1 year	2018	1.8	-13.866 -3.3393
Implementation: Use data from Sea Around Us in line with assessment direction of Yale University and Columbia University					
Indicator on Fish Caught by Trawling and Dredging					
<i>Definition: Indicator on Fish Caught by Trawling and Dredging means the percentage of marine animals caught by trawling and dredging to the total marine animals caught in Exclusive Economic Zone in Thailand.</i>					
Marine animals caught by trawling and dredging	Department of Fisheries	1 year	2022	1.4	-16.2924 -0.0362
Implementation: Use data from government agencies in Thailand					
Indicator on Sulfur dioxide (SO₂) Growth Rate					
<i>Definition: Indicator on Sulfur dioxide (SO₂) Growth Rate means sulfur dioxide emission rate over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories.</i>					
Sulfur dioxide emission rate	Department of Climate Change and Environment	10 years	2010 - 2019	2	-0.0394 0.1110

(PPP, constant 2017 international\$)	World Bank & IMF				
Implementation: Use data from government agencies in Thailand					
Indicator on Nitrogen oxide (NO_x) Growth Rate					
<i>Definition: Indicator on Nitrogen Oxide (NO_x) Growth Rate means nitrogen oxide emission rate over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories.</i>					
Nitrogen oxide emission rate	Department of Climate Change and Environment	10 years	2010 - 2019	2	-0.0394 0.0945
Gross Domestic Product (PPP, constant 2017 international\$)	World Bank & IMF				
Implementation: Use data from government agencies in Thailand					
Indicator on Sustainable Nitrogen Management Index					
<i>Definition: Indicator on Sustainable Nitrogen Management Index means the measurement of environmental performance of agricultural production to seek the balance of efficient application of nitrogen fertilizer with maximum crop yields by setting agricultural efficiency in 2 aspects including Nitrogen Use Efficiency (NUE) and Land Utilization (crop yields).</i>					
Crop cultivation area, harvested area and yield	Office of Agricultural Economics	1 year	2022	2	0.0 1.3641
Crop cultivation area, harvested area and yield (sugarcane)	Office of the Cane and Sugar Board				
Fertilizer use (fixed value)	Department of Agriculture				
Manure use and annual nitrogen accumulation rate	Bouwman et al., 2013				
Annual nitrogen fixation rate	Zhang et al., 2015				
Implementation: Use data from government agencies in Thailand					
Indicator on Sustainable Pesticide Use					
<i>Definition: Indicator on Sustainable Pesticide Use means the responsible application of pesticide use for the benefit of food security while at the same time realizing that over-application of pesticide damages the environment. A newly-developed indicator is known as “pesticide risk score” based on a country’s pesticide application rate.</i>					
Pesticide risk score (PRS)	Tang et al., 2021	1 year	2015	2	0.0 4.5

Pesticide application rate (APR) (kg ha ⁻¹ yr ⁻¹)	Maggi et al., 2019				
Implementation: Use research data in line with assessment direction of Yale University and Columbia University					
Indicator on Wastewater Treatment					
<i>Definition: Indicator on Wastewater Treatment means the ability to treat wastewater of communities and the access to community wastewater treatment system of population.</i>					
Total amount of wastewater, amount of treated wastewater, number of people access to wastewater treatment services	Pollution Control Department	1 year	2022	3	1 0
Annual population	Department of Provincial Administration				
Implementation: Use data from government agencies in Thailand					

3.2.2 Draft Environmental Performance Index in the Context of Thailand or EPI Thailand

Environmental Performance Index developed by Yale University and Columbia University uses data in calculation for the comparison of performance of countries across the globe. Therefore, the data had limitation of not being able to directly represent the performance of Thailand such as data of satellite images or aerial photographs adjusted with mathematical models, adjusted data to align information in the same pattern or assessment method, and outdated data from researches or international databases.

Therefore, the Environmental Performance Index in the context of Thailand (EPI Thailand) has been drafted. It uses calculation format by compiling data directly from agencies in the country and it is also in line with policies and plans of Thailand. **The Draft EPI Thailand comprises 11 Issue Categories and 40 Indicators**, covers Policy Objectives on Environmental Health that focuses on air quality, sanitation & drinking water; Policy Objective on Climate Change that emphasizes climate change mitigation and Policy Objective on Ecosystem Vitality that focuses on biodiversity & habitat, ecosystem services, fisheries, acid rain, agriculture and water resource. Indicators, definitions, using data, weighted average and EPI operational benchmarks (Best – Worst) of EPI Thailand in 2022 is demonstrated in Table 3. **The score of EPI Thailand was at 78.0.**

Table 3: Indicators, definitions, using data, weights and EPI operational benchmarks (Best – Worst) of EPI Thailand

Using data	Data sources/ agencies	Data period	Data year	Weights (wt.)	Performance Best-Worst
Indicator on PM_{2.5} Exposure					
<i>Definition: Indicator on PM_{2.5} Exposure for EPI Thailand measures from the population-weighted annual average concentration of the air pollutant.</i>					
PM _{2.5} concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	5.2	100 0
Air quality standard in general atmosphere					
Population in districts of measurement station locations	Department of Provincial Administration				
Indicator on usage of Household Solid Fuels					
<i>Definition: Indicator on usage of Household Solid Fuels for EPI Thailand measures from the population-weighted annual average concentration of the air pollutant.</i>					
Percentage of households using solid fuels in cooking	National Statistical Office	1 year	2021	4.2	0 100
Average energy generated from usage of household solid fuels in one year	Department of Alternative Energy Development and Efficiency		2022		
Indicator on Ozone Exposure					
<i>Definition: Indicator on Ozone Exposure for EPI Thailand measures from the population-weighted annual average concentration of the air pollutant.</i>					
Ozone concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	0.5	100 0
Air quality standard in general atmosphere					
Population in districts of measurement station locations	Department of Provincial Administration				
Indicator on Nitrogen oxide (NO_x) Exposure					
<i>Definition: Indicator on Nitrogen oxide (NO_x) Exposure for EPI Thailand measures from the population-weighted annual average concentration of the air pollutant.</i>					

Using data	Data sources/ agencies	Data period	Data year	Weights (wt.)	Performance Best-Worst
NO ₂ concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	0.5	100 0
Air quality standard in general atmosphere					
Population in districts of measurement station location	Department of Provincial Administration				
Indicator on Sulfur dioxide (SO₂) Exposure					
<i>Definition: Indicator on Sulfur dioxide (SO₂) Exposure for EPI Thailand measures from the population-weighted annual average concentration of the air pollutant.</i>					
SO ₂ concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	0.2	100 0
Air quality standard in general atmosphere					
Population in districts of measurement station locations	Department of Provincial Administration				
Indicator on Carbon monoxide (CO) Exposure					
<i>Definition: Indicator on Carbon monoxide (CO) Exposure for EPI Thailand measures from the population-weighted annual average concentration of the air pollutant.</i>					
CO concentration at measurement stations (annual average)	Pollution Control Department	1 year	2022	0.2	100 0
Air quality standard in general atmosphere					
Population in districts of measurement station locations	Department of Provincial Administration				
Indicator on Volatile Organic Compounds (VOCs) Exposure					
<i>Definition: Indicator on Volatile Organic Compound (VOC) Exposure for EPI Thailand from the population-weighted annual average concentration of the air pollutant.</i>					
Concentration of 9 types of VOCs at	Pollution Control Department	1 year	2022	0.2	100 0

Using data	Data sources/ agencies	Data period	Data year	Weights (wt.)	Performance Best-Worst
measurement stations (annual average)					
Air quality standard in general atmosphere					
Indicator on Unsafe Sanitation					
<i>Definition: Indicator on Unsafe Sanitation for EPI Thailand measures from the access to hygienic sanitation and risk from unhygienic sanitation.</i>					
Percentage of households with hygienic toilets	National Statistical Office	1 year	2022	2	100 0
<i>Age-standardized disability-adjusted life- years lost (DALYs) from unsafe sanitation</i>	International Health Policy Program	1 year	2019		0 84.0441
Indicator on Clean and Safe Drinking Water					
<i>Definition: Indicator on Clean and Safe Drinking Water for EPI Thailand measures from the access to clean and safe drinking water and risk from unsafe drinking water.</i>					
Number of households using water under residential type	1. Provincial Waterworks Authority 2. Metropolitan Waterworks Authority	1 year	2022	3	100 0
Number of households using village tap water throughout the year	Community Development Department				
Percentage of household tap water passing Department of Health's drinking water quality standard B.E. 2563	Department of Health				
Total households in Thailand	Department of Provincial Administration				
<i>Age-standardized disability-adjusted life- years lost (DALYs) from unsafe drinking water</i>	International Health Policy Program	1 year	2019		0 111.1695
Indicator on Sickness Rate from Lead Poisoning					
<i>Definition: Indicator on Sickness Rate from Lead Poisoning for EPI Thailand measures from sickness rate caused by lead poisoning in all cases.</i>					

Using data	Data sources/ agencies	Data period	Data year	Weights (wt.)	Performance Best-Worst
Sickness rate from lead poisoning in all cases	Office of the Permanent Secretary, Ministry of Public Health	1 year	2022	2	0 16.17
Indicator on Controlled Solid Waste					
<i>Definition: Indicator on Controlled Solid Waste for EPI Thailand means the proportion of household and commercial waste generated in a country that is collected and treated in a manner that controls environmental risks.</i>					
Amount of solid waste	Pollution Control Department	1 year	2022	1	1.0 0.0
Indicator on Recyclable Solid Waste Recycling Rate					
<i>Definition: Indicator on Recyclable Solid Waste Recycling Rate for EPI Thailand means the proportion of post-consumer recyclable materials (glass, plastic, paper, and metal) that is recycled.</i>					
Components of solid waste separated at landfill sites	Pollution Control Department	1 year	2022	0.5	1.0 0.0
Proportion of recycled waste	Chen et al., 2020	1 year	2020		
Indicator on Floating Marine Debris at Main Estuaries					
<i>Definition: Indicator on Floating Marine Debris at Main Estuaries for EPI Thailand means the measurement in pieces of plastic at estuaries of 5 rivers in Thailand, namely Chao Phraya, Mae Klong, Tha Chin, Bang Pakong and Bang Taboon.</i>					
Quantity of debris released into the sea through major rivers at upper Gulf of Thailand (pieces per year)	Department of Marine and Coastal Resources	1 year	2022	0.5	738 3357
Indicator on Carbon dioxide (CO₂) Growth Rate					
<i>Definition: Indicator on Carbon dioxide (CH₂) Growth Rate for EPI Thailand means carbon dioxide emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
CO ₂ emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	21.7	0.0139 0.0337
Gross Domestic Product-Chain Volume Measures (Reference year of 2002)	Office of the National Economic and Social Development Council				

Exchange rate (Baht to one US dollar)	Bank of Thailand				
Indicator on Methane (CH₄) Growth Rate					
<i>Definition: Indicator on Methane (CH₄) Growth Rate for EPI Thailand means methane emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
CH ₄ emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	5.18	-0.0102 0.0324
Gross Domestic Product-Chain Volume Measures (Reference year of 2002)	Office of the National Economic and Social Development Council				
Exchange rate (Baht to one US dollar)	Bank of Thailand				
Indicator on Nitrous oxide (N₂O) Growth Rate					
<i>Definition: Indicator on Nitrous oxide (N₂O) Growth Rate for EPI Thailand means nitrous oxide emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
N ₂ O emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	1.1	0.0076 0.0398
Gross Domestic Product-Chain Volume Measures (Reference year of 2002)	Office of the National Economic and Social Development Council				
Exchange rate (Baht to one US dollar)	Bank of Thailand				
Indicator on Fluorinated gas (F-gas) Growth Rate					
<i>Definition: Indicator on Fluorinated gas (F-gas) Growth Rate for EPI Thailand means fluorinated gas emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not land use, land-use change and forestry. Sources of fluorinated gas considered by Yale University and Columbia University are HFCs, PFCs and SF₆ that released from industrial process and product usage.</i>					
F-gas emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	2.2	0.1074 0.3488

Indicator on Black Carbon Growth Rate					
<i>Definition: Indicator on Black Carbon Growth Rate for EPI Thailand means black carbon emissions over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. Sources of black carbon considered by Yale University and Columbia University are releasing sources from energy and waste sectors.</i>					
Fuel quantity of energy sector	Department of Alternative Energy Development and Efficiency	10 years	2010 - 2019	1.57	-0.0109 0.0376
Emissions from biomass burning from sectors of agriculture, forestry, land use and burning waste in incinerators of the waste sector.	Department of Climate Change and Environment				
Gross Domestic Product-Chain Volume Measures (Reference year of 2002)	Office of the National Economic and Social Development Council				
Exchange rate (Baht to one US dollar)	Bank of Thailand				
Indicator on Carbon dioxide (CO₂) from Land Cover					
<i>Definition: Indicator on Carbon dioxide (CO₂) from Land Cover for EPI Thailand means carbon dioxide emission rate generated from change in land utilization over time, caused from tree cover change by considering above-ground and underground biomass and dead wood. Then assess carbon dioxide emission using recommended emission factors from the Guidelines for National Greenhouse Gas Inventories.</i>					
CO ₂ emission rate from land cover	Department of Climate Change and Environment	10 years	2010 - 2019	2.36	-0.0951 0.0588
Indicator on Greenhouse gas (GHG) per Capita					
<i>Definition: Indicator on Greenhouse gas (GHG) per Capita for EPI Thailand means the emission of all greenhouse gases (carbon dioxide, methane, nitrous oxide and fluorinated group) per one person, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
Quantity of greenhouse gas emission (excluding LULUCF)	Department of Climate Change and Environment	1 year	2010 - 2019	1.57	0.0053 0.0318
Population	Department of Provincial Administration				

Indicator on Greenhouse gas (GHG) to Gross Domestic Product or GHG Intensity Trend (GIB)					
<i>Definition: Indicator on Greenhouse gas (GHG) to Gross Domestic Product for EPI Thailand means the emission of all greenhouse gases (carbon dioxide, methane, nitrous oxide and fluorinated group) per Gross Domestic Product over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
GHG emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	2.36	-0.0443 0.0018
Gross Domestic Product-Chain Volume Measures (Reference year of 2002)	Office of the National Economic and Social Development Council				
Exchange rate (Baht to one US dollar)	Bank of Thailand				
Indicator on Thailand's Terrestrial Biome Protection					
<i>Definition: Indicator on Thailand's Terrestrial Biome Protection for EPI Thailand means the proportion of essential terrestrial biome under the protected area, weighted by the proportion of distribution of each type of terrestrial biome in the country in order to achieve the country's targets of conservation areas.</i>					
Forest areas	Royal Forest Department	10 years	2013 - 2022	4	25 0
Conservation areas	Department of National Park, Wildlife and Plant Conservation				
Indicator on Thailand's Terrestrial Biome Protection of International Importance					
<i>Definition: Indicator on Thailand's Terrestrial Biome Protection of International Importance for EPI Thailand means proportion of terrestrial biome of Thailand with international importance in protected areas, weighted by the world's biome areas.</i>					
Area of Natural World Heritage Sites/ ASEAN Heritage Parks/ Biosphere reserves and wetland with international importance (Ramsar Site)	Department of National Park, Wildlife and Plant Conservation	10 years	2013 - 2022	4	17 0
Area of wetland with international importance (Ramsar Site)	Department of Water Resources				
Area of biosphere reserve (Sakaerat)	Thailand Institute of Scientific and Technological Research				

Area of biosphere reserve (Ngao)	Department of Marine and Coastal Resources				
Indicator on Proportion of Marine Conservation Areas to the Area of Thai Waters					
<i>Definition: Indicator on Proportion of Marine Conservation Areas to the Area of Thai Waters for EPI Thailand means proportion of marine protected areas to overall Thai waters areas that reflects the protection of marine ecosystem.</i>					
Marine protected areas and Thailand's waters	Department of Marine and Coastal Resources	1 year	2022	2	30 0
Indicator on Terrestrial Conservation Areas to Thai Terrestrial Areas					
<i>Definition: Indicator on Terrestrial Conservation Areas to Thai Terrestrial Areas for EPI Thailand means proportion of terrestrial protected areas or conservation areas under the responsibility of Department of National Park, Wildlife and Plant Conservation to overall Thai terrestrial areas.</i>					
Conservation areas	Department of National Park, Wildlife and Plant Conservation	1 year	2022	3	30 0
Thailand's Total areas	Royal Forest Department				
Indicator on Population of Endangered Species					
<i>Definition: Indicator on Population of Endangered Species for EPI Thailand means the data on the population of Thailand's vertebrates, namely tigers, dugongs, Irrawaddy dolphins and turtles that are threatened of becoming extinct.</i>					
Tiger population	Department of National Park, Wildlife and Plant Conservation	1 year	2022	3	1 0
Population of dugongs, Irrawaddy dolphins, Hawksbill turtles, Green turtles, Leatherback turtles and Olive Ridley turtles	Department of Marine and Coastal Resources				
Indicator on Number of protected areas being evaluated for management effectiveness					
<i>Definition: Indicator on Number of protected areas being evaluated for management effectiveness for EPI Thailand means number of protected areas that been evaluated for management effectiveness including protected terrestrial areas (national parks and wildlife sanctuaries), marine protected areas and environment protected areas to total protected areas.</i>					
Number of protected areas being evaluated for management effectiveness	1. Department of National Park, Wildlife and Plant Conservation 2. Department of Marine and Coastal Resources 3. Office of Natural Resources and	1 year	2022	2	100 0

	Environmental Policy and Planning				
Indicator on Tree Cover Loss					
<i>Definition: Indicator on Tree Cover Loss for EPI Thailand means the measurement of the average annual loss in forest area over the past 5 years, divided by the total extent of forest area in the base year.</i>					
Forest areas	Royal Forest Department	5 years	2018 - 2022	4	-13.846 -4.5822
Indicator on Wetland Loss					
<i>Definition: Indicator on Wetland Loss for EPI Thailand means the measurement of the average annual loss in wetland area over the past 5 years, divided by the total extent of forest area in 1992.</i>					
Wetland areas	1. Land Development Department 2. Department of Water Resources	5 years	2017 - 2022	2	-10.5632 -2.4422
Indicator on Mangrove Loss					
<i>Definition: Indicator on Mangrove Loss for EPI Thailand means the annual average loss of mangrove forests in the past, divided by total extent of mangrove forest in the base year.</i>					
Mangrove areas	Department of Marine and Coastal Resources	11 years	2009 - 2019	1	-12.9113 -5.5935
Indicator on Integrity of seagrass					
<i>Definition: Indicator on Integrity of seagrass for EPI Thailand means the level of Integrity in percentage of seagrass cover.</i>					
Integrity of seagrass	Department of Marine and Coastal Resources	2 years	2021 - 2022)	0.5	1 0
Indicator on Integrity of coral reefs					
<i>Definition: Indicator on Integrity of coral reefs for EPI Thailand means the ratio of areas covered by living coral and dead coral in percentage of the whole areas.</i>					
Integrity of coral reefs	Department of Marine and Coastal Resources	2 years	2021 - 2022	0.5	1 0
Indicator on Fish Stock Status					
<i>Definition: Indicator on Fish Stock Status for EPI Thailand means the percentage of a country's total catch that comes from overexploited or collapsed stocks, considering all fish stocks within the country's Exclusive Economic Zone (EEZ).</i>					
Marine animal catches	Department of Fisheries	10 years	2013 - 2022	2.5	3 2
Indicator on Abundance of Demersal Fauna					
<i>Definition: Indicator on Abundance of Demersal Fauna for EPI Thailand means the measurement in percentage of quantity of demersal fauna catches per unit effort in the calculating year to the quantity of demersal fauna catches per unit effort at point with sustainable maximum yields.</i>					
Quantity of demersal fauna catches	Department of Fisheries	1 year	2022	2.5	100 0
Catch per unit effort					

Indicator on Sulfur dioxide (SO₂) Growth Rate					
<i>Definition: Indicator on Sulfur dioxide (SO₂) Growth Rate for EPI Thailand means sulfur dioxide emission rate over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
Sulfur dioxide emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	2	-0.05 -0.0007
Gross Domestic Product-Chain Volume Measures (Reference year of 2002)	Office of the National Economic and Social Development Council				
Exchange rate (Baht to one US dollar)	Bank of Thailand				
Indicator on Nitrogen oxide (NO_x) Growth Rate					
<i>Definition: Indicator on Nitrogen oxide (NO_x) Growth Rate for EPI Thailand means Nitrogen oxide emission rate over time, generated by human activities under the assessment framework set in the Guidelines for National Greenhouse Gas Inventories. It is the emissions released by various sectors but not include land use, land-use change and forestry.</i>					
Nitrogen oxide emission growth rate	Department of Climate Change and Environment	10 years	2010 - 2019	2	0.0141 0.0312
Gross Domestic Product-Chain Volume Measures (Reference year of 2002)	Office of the National Economic and Social Development Council				
Exchange rate (Baht to one US dollar)	Bank of Thailand				
Indicator on Sustainable Nitrogen Management Index					
<i>Definition: Indicator on Sustainable Nitrogen Management Index for EPI Thailand means the measurement of environmental performance of agricultural production to seek the balance of efficient application of nitrogen fertilizer with maximum crop yields by setting agricultural efficiency in two aspects including Nitrogen Use Efficiency (NUE) and Land Utilization (crop yields).</i>					
Crop cultivation area, harvested area and yield	Office of Agricultural Economics	1 year	2022	4	0.68 0.84
Crop cultivation area, harvested area and yield (sugarcane)	Office of the Cane and Sugar Board				
Fertilizer use (fixed value)	Department of Agriculture				

Manure use and annual nitrogen accumulation rate	Bouwman et al., 2013				
Annual nitrogen fixation rate	Zhang et al., 2015				
Indicator on Wastewater Treatment					
<i>Definition: Indicator on Wastewater Treatment for EPI Thailand means the ability to treat wastewater of communities and the access to community wastewater treatment system of population.</i>					
Total amount of wastewater, amount of treated wastewater, number of people access to wastewater treatment services	Pollution Control Department	1 year	2022	1	10
Annual population	Department of Provincial Administration				
Indicator on Water Quality					
<i>Definition: Indicator on Water Quality for EPI Thailand means the percentage of number of surface water sources in Thailand with water quality in good condition, based on the Surface Water Quality Index.</i>					
Number of surface water sources with quality at different levels	Pollution Control Department	1 year	2022	1	100
Indicator on Water Stress Performance					
<i>Definition: Indicator on Water Stress Performance for EPI Thailand means the score level of water stress that demonstrates the percentage of available usable water after the deduction of weighted water stress.</i>					
Water stress	Office of the National Water Resources	1 year	2019	1	100

Conclusion of results of Environmental Performance Index developed by the cooperation between Yale University and Columbia University with the most recent published report EPI Yale & Columbia 2022, Environmental Performance Index using data from agencies in Thailand (EPI+) 2022 and Draft Environmental Performance Index in the context of Thailand (EPI Thailand), Indicators, Issue Categories, Policy Objectives and overall situation. They are demonstrated in Table 4.

Results of the assessment of operational effectiveness are as follows.

● **Red** means Performance under assessment framework is at low level (score 0 – 25.0)

● **Orange** means Performance under assessment framework is at moderate level (score 25.1 – 50.0)

● **Yellow** means Performance under assessment framework is at good level (score 50.1 – 75.0)

● **Green** means Performance under assessment framework is at outstanding level (score 75.1 – 100)

Table 4: Results of assessment scores by EPI Yale & Columbia, EPI+ and draft EPI Thailand in 2022

EPI Yale & Columbia/ EPI +	Score		Draft EPI Thailand	Score
	EPI Yale & Columbia	EPI +		
Overall	38.1	49.6	Overall	78.0
Policy Objective on Environmental Health	43.8	49.9	Policy Objective on Environmental Health	62.1
Issue Category on Air Quality	34.4	35.6	Issue Category on Air Quality	52.4
PM _{2.5} Exposure	33.3 ●	33.3 ●	PM _{2.5} Exposure	32.1 ●
Household Solid Fuels	39.9 ●	39.9 ●	Household Solid Fuels	64.2 ●
Ozone Exposure	42.4 ●	42.4 ●	Ozone Exposure	84.4 ●
Nitrogen oxide (NO _x) Exposure	15.2 ●	25.7 ●	Nitrogen oxide (NO _x) Exposure	85.3 ●
Sulfur dioxide (SO ₂) Exposure	17.1 ●	69.3 ●	Sulfur dioxide (SO ₂) Exposure	98.2 ●
Carbon monoxide (CO) Exposure	17.5 ●	3.7 ●	Carbon monoxide (CO) Exposure	97.6 ●
Volatile Organic Compounds (VOCs) Exposure	11.0 ●	11.0 ●	Volatile Organic Compounds (VOCs) Exposure	79.4 ●
Issue Category on Sanitation & Drinking Water	55.9	69.5	Issue Category on Sanitation & Drinking Water	69.8
Unsafe Sanitation	75.8 ●	83.9 ●	Unsafe Sanitation	96.5 ●
Unsafe Drinking Water	42.7 ●	59.8 ●	Clean and Safe Drinking Water	52.0 ●
Issue Category on Heavy metals	80.7	80.7	Issue Category on Heavy metals	95.4
Lead Exposure	80.7 ●	80.7 ●	Lead Poisoning Rate	95.4 ●
Issue Category on Waste Management	28.5	48.6	Issue Category on Waste Management	62.6
Controlled Solid Waste	35.4 ●	72.4 ●	Controlled Solid Waste	72.4 ●
Recycling Rate	40.0 ●	36.3 ●	Recycling Rate	36.3 ●
Ocean Plastic Pollution	3.1 ●	13.2 ●	Floating Marine Debris from Major Rivers	69.4 ●

EPI Yale & Columbia/ EPI +	Score		Draft EPI Thailand	Score
	EPI Yale & Columbia	EPI +		
Policy Objective on Climate Change	36.0	32.9	Policy Objective on Climate Change	89.5
Issue Category on Climate Change Mitigation	36.0	32.9	Issue Category on Climate Change Mitigation	89.5
Carbon dioxide (CO ₂) Growth Rate	41.6 ●	40.2 ●	Carbon dioxide (CO ₂) Growth Rate	95.3 ●
Methane (CH ₄) Growth Rate	71.5 ●	50.4 ●	Methane (CH ₄) Growth Rate	76.9 ●
Nitrous oxide (N ₂ O) Growth Rate	77.6 ●	56.0 ●	Nitrous oxide (N ₂ O) Growth Rate	82.1 ●
Fluorinated gas (F-gas) Growth Rate	100 ●	34.3 ●	Fluorinated gas (F-gas) Growth Rate	95.7 ●
Black Carbon Growth Rate	54.8 ●	89.8 ●	Black Carbon Growth Rate	95.2 ●
Carbon dioxide (CO ₂) from Land Cover	30.2 ●	90.0 ●	Carbon dioxide (CO ₂) from Land Cover	100 ●
Greenhouse gas (GHG) per Capita	42.0 ●	44.1 ●	Greenhouse gas (GHG) per Capita	91.8 ●
Greenhouse gas (GHG) to Gross Domestic Product or GHG Intensity Trend (GIB)	60.0 ●	52.2 ●	Greenhouse gas (GHG) to Gross Domestic Product or GHG Intensity Trend (GIB)	46.0 ●
Projected Greenhouse gas (GHG) Emissions in 2050	9.5 ●	8.8 ●		
Policy Objective on Ecosystem Vitality	37.3	63.5	Policy Objective on Ecosystem Vitality	75.2
Issue Category on Biodiversity & Habitat	51.4	70.4	Issue Category on Biodiversity & Habitat	62.8
Terrestrial Biome Protection (national)	75.7 ●	100 ●	Thailand's Terrestrial Biome Protection	85.9 ●
Terrestrial Biome Protection (global)	46.6 ●	100 ●	Thailand's Terrestrial Biome Protection of International Importance	100 ●
Marine Protected Areas	44.6 ●	52.2 ●	Proportion of Marine Conserved Areas to the Area of Thai Waters	17.4 ●
Protected Areas Representativeness Index	26.8 ●	26.8 ●		
Species Protection Index	71.8 ●	71.8 ●		
Species Habitat Index	70.1 ●	70.1 ●		
Biodiversity Habitat Index	31.8 ●	31.8 ●		
			Terrestrial Conservation Areas to Thai Terrestrial Areas	70.7 ●

EPI Yale & Columbia/ EPI +	Score		Draft EPI Thailand	Score
	EPI Yale & Columbia	EPI +		
			Population of Endangered Species	44.2 ●
			Number of Protected Areas being Evaluated for Management Effectiveness	3.8 ●
Issue Category on Ecosystem Services	15.3	87.0	Issue Category on Ecosystem Services	94.9
Tree Cover Loss	9.8 ●	99.4 ●	Tree Cover Loss	99.3 ●
Wetland Loss	22.5 ●	100 ●	Wetland Loss	100 ●
Grassland Loss	41.2 ●	0 ●		
			Mangrove Loss	100 ●
			Integrity of Seagrass	66.7 ●
			Integrity of Coral Reef	57.0 ●
Issue Category on Fisheries	12.9	43.0	Issue Category on Fisheries	94.2
Fish Stock Status	11.9 ●	100 ●	Fish Stock Status	100 ●
Regional Marine Trophic Index	15.3 ●	15.3 ●		
Fish Caught by Trawling and Dredging	10.9 ●	5.4 ●		
			Abundance of Demersal Fauna	88.5 ●
Issue Category on Acid Rain	79.8	80.0	Issue Category on Acid Rain	80.3
Sulfur dioxide (SO ₂) Growth Rate	100 ●	100 ●	Sulfur dioxide (SO ₂) Growth Rate	60.6 ●
Nitrogen oxide (NO _x) Growth Rate	59.5 ●	60.1 ●	Nitrogen oxide (NO _x) Growth Rate	100 ●
Issue Category on Agriculture	33.0	39.9	Issue Category on Agriculture	72.8
Sustainable Nitrogen Management Index	33.1 ●	47.0 ●	Sustainable Nitrogen Management Index	72.8 ●
Sustainable Pesticide Use	32.9 ●	32.9 ●		
Issue Category on Water Resources	1.8	2.6	Issue Category on Water Resources	60.9
Wastewater Treatment	1.8 ●	2.6 ●	Wastewater Treatment	2.6 ●
			Water Quality	92.9 ●
			Water Stress Performance	87.4 ●

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● Score 0 - 25.0

● Score 25.1 - 50.0

● Score 50.1 - 75.0

● Score 75.1 - 100

Conclusion

From the concept and performance as shown in the above tables, Office of Natural Resources and Environmental Policy and Planning has an opinion that despite having a study on EPI Thailand, it is still necessary to compile data and calculate the EPI+ index every year in order to benchmark the country's performance on natural resources and environment at international level. This will lead to the improvement in policies and operational plans of relevant agencies, resulted in upgrading the EPI score of Thailand at international level in the future.

However, there were additional recommendations in details of indicators of the draft EPI Thailand at the seminar for driving and integrating of participating networks in preparing Thailand Environmental Performance Index under the second phase of the preparation of Environmental Performance Index Project on 12 July 2023 at the Berkeley Hotel Pratunam. The Office will factor in those recommendations in the preparation of EPI Thailand to ensure the accuracy, completeness and consistency with the context of Thailand and the country's policies and planning in the future.

Chapter 4 Driving Thailand Environmental Performance Index

Chapter 4 discusses tools for driving Thailand Environmental Performance Index covering management plans for Environmental Performance Index of Thailand, database, and awareness creation among the general public and related agencies. This chapter also provides information about operation mechanisms that include data reporting agencies and policy mechanisms that are essential for the achievement of effective results.

4.1 Driving tools

4.1.1 Management Plan of Thailand Environmental Performance Index

Management plan of Thailand Environmental Performance Index is the practice guideline for related agencies in collecting and compiling data for the assessment of Thailand Environmental Performance Index for both EPI+ and EPI Thailand in order to effectively, continuously and sustainably prepare and report the results of Thailand Environmental Performance Index. The management plan comprises structure of data collection and reporting, period of data submission to Office of Natural Resources and Environmental Policy and Planning and year of data submission. Details of agencies and required detailed data from agencies for assessment of EPI+ and EPI Thailand are exhibited in Appendix B.

4.1.2 Database of Thailand Environmental Performance Index

At the initial stage, the database of Thailand Environmental Performance Index is designed for import, store, compile and process data from template in form of Excel sheets submitted by responsible agencies. The data is used in the calculation formular and variables of each Issue Category. The score will be weighted and the results of Environmental Performance Index are presented as overall score, Issue Category and Indicator for both EPI+ and EPI Thailand.

4.1.3 Awareness Creation

Office of Natural Resources and Environmental Policy and Planning is the focal point agency in compiling information from the database of Thailand Environmental Performance Index for dissemination to the public through seminars and report of Thailand State of Environmental Performance Index. The Office also prepares public relations media in form of Infographics and videos for different parties such as government agencies, private sectors, educational institutions and the general public. Information is also available via the website <https://www.onep.go.th>.

4.2 Operation Mechanism

1) There are 25 government agencies providing data for EPI assessment. They are Department of Provincial Administration, Department of Climate Change and Environment, Community Development Department, Pollution Control Department, Department of Marine and Coastal Resources, Department of Water Resources, Department of Fisheries, Royal Forest Department, Land Development Department, Department of Alternative Energy Development and Efficiency, Department of Agriculture, Department of Health, Department of National Park, Wildlife and Plant Conservation, Office of the Permanent Secretary, Ministry of Public Health, Metropolitan Waterworks Authority, Provincial Waterworks Authority, Bank of Thailand, Thailand Institute of Scientific and Technological Research, Office of the Cane and Sugar Board, Office of Natural Resources and Environmental Policy and Planning, International Health Policy Program, Office of Agricultural Economics, National Statistical Office, Office of the National Economic and Social Development Council, and Office of the National Water Resources. They submit data to the Office of Natural Resources and Environmental Policy and Planning for compiling and processing the score for EPI+ and EPI Thailand.

2) Policy mechanism: The implementation and assessment result of Environmental Performance Index has been proposed to the Subcommittee for the Management of Thailand Environmental Performance Index, chaired by Permanent Secretary of the Ministry of Natural Resources and Environment. Representatives from related agencies are members of the subcommittee and Office of Natural Resources and Environmental Policy and Planning acts as the secretariat. The subcommittee has the main responsibility in coordinating for the operation and supporting information for the preparation of Thailand Environmental Performance Index which is applied for evidence-based policy decision making. The subcommittee also promotes and supports implementations related to Thailand Environmental Performance Index, the order of appointment of the subcommittee is shown in appendix C. Then, the issues are proposed to the National Environment Board for consideration, respectively.

Chapter 5 Conclusion

Chapter 5 emphasizes the benefits that Thailand and government agencies will receive from the preparation of Thailand Environmental Performance Index, the challenge in index preparation, the driving of Thailand Environmental Performance Index as well as policy recommendations.

5.1 Benefits of Thailand Environmental Performance Index

In the preparation of Environmental Performance Index in the context of Thailand or EPI Thailand, there are selected indicators and calculation pattern that consist with the context of Thailand and relating to Thailand's policies and plans. It can be used to assess the efficiency in maintaining the country's natural resources and environment. The EPI Thailand also helps identify operational efficiency of each agency in solving environmental problems at the origin, which will benefit the policy charting. It is used as supportive information for each agency in seeking budget allocation to match problematic areas and missions under the agencies' responsibility. The report is also used in the preparation of recommendations to support the attempt to drive Thailand toward sustainable development.

5.2 Challenge in Preparing and Driving of Thailand Environmental Performance Index

Technical Academic Aspect

(1) Data completeness/continuity such as incomplete data of air quality at some measurement stations, continuity of collection of sickness rate from lead poisoning by Health Data Center, continuity of data collection of the amount of floating marine debris and integrity of data about fluorinated gas emissions.

(2) Inconsistent in details of data used by Yale University and Columbia University (EPI Yale & Columbia) with information from Thailand. For example, Thailand has started assessing Disability-adjusted Life Year (DALYs) but the nature of diseases and input factors do not match the data of EPI Yale & Columbia. Regarding Indicator on Volatile Organic Compounds (VOCs) Exposure, Yale University and Columbia University use the value of concentration of 4 volatile organic compounds, namely Ethane, Propane, Formaldehyde and Isoprene. However, Thailand has data on the measurement of Acetaldehyde, Acrolein, Acrylonitrile, Benzene, Benzyl chloride, 1,3-Butadiene, Bromomethane, Carbon tetrachloride and Chloroform. These are different compounds from the information used by EPI Yale & Columbia. Moreover, Thailand collects data of volatile organic compounds only in pollution control areas.

(3) Frequency and reporting period as some government agencies do not collect information annually, or having data collection plans beyond the deadline of data submission. Therefore, the submitted data is not the current dataset.

(4) Dissemination and Thailand's data submission to international organizations or databases, providing them with the ability to access current information from Thailand.

(5) Readiness for applying tools by government agencies in Thailand such as Management Effectiveness Tracking Tool because Thailand is still in the early stage of operation so officials still lack knowledge and understanding about the tool and assessment method.

Budgetary Aspect

Limitation on budget and personnel in collecting, compiling and submitting data.

5.3 Policy Recommendations

1) Accelerating implementation of driving activities/ projects consistent with or support the elevation of score of indicators of Thailand Environmental Performance Index, particularly indicators with low or moderate score levels.

2) Supporting the preparation/ dissemination/ rapid submission of Thailand's information to international organizations or databases, providing them with the ability to access current information from Thailand. This will help to ensure accuracy and efficiency in the study or assessment of operations in Thailand, and benefit in term of precise policy setting and planning.

3) Continuously building awareness and understanding about the measurement and assessment results of Environmental Performance Index among all parties including government agencies, private sectors, educational institutions and civil society. Therefore, related parties can use the information for setting or adjusting policies and plans in line with the framework on national and global development.

4) Transfer information about Thailand Environmental Performance Index particularly EPI Thailand to regions and provinces by designing appropriate knowledge transfer models and directions that consistent with situations and the context of particular areas. This aims to strengthen the management of local natural resources and environment, that will influence the upgrading of Thailand Environmental Performance Index in the future.

2006	2008	2010	2012	2014	2016	2018	2023	2022
		Biome Protection	Biome Protection	Global Biome Protection	Terrestrial Biome Protect. (global)	Biome Protection (global)	Terrestrial Biome Protect. (global)	Terrestrial Biome Protect. (global)
				National Biome Protection	Terrestrial Biome Protect. (national)	Biome Protection (national)	Terrestrial Biome Protect. (national)	Terrestrial Biome Protect. (national)
						Species Habitat Index	Species Habitat Index	Species Habitat Index
					Species Protection (global)			
					Species Protection (National)	Species Protection Index	Species Protection Index	Species Protection Index
						Representativeness Index	Protected Areas Representativeness Index	Protected Areas Representativeness Index
Issue Category on Forest / Ecosystem Services								
3.33	2.5	4.2	5.83	10	10	6	6	8
Timber Harvest Rate	Growing stock change	Growing stock change	Forest Growing Stock					
		Forest Cover Change	Change in Forest Cover	Change in Forest Cover				
			Forest Loss		Tree Cover Loss	Tree Cover Loss	Tree Cover Loss	Tree Cover Loss
							Grassland Loss	Grassland Loss
							Wetland Loss	Wetland Loss

2006	2008	2010	2012	2014	2016	2018	2023	2022
Issue Category on Fisheries								
3.33	2.5	4.2	5.83	10	2.5	6	6	5
Overfishing	Marine trophic index	Marine trophic index				Regional Marine Trophic Index	Regional Marine Trophic Index	Regional Marine Trophic Index
	Trawling intensity	Trawling intensity					Fish Caught by Trawling	Fish Caught by Trawling and Dredging
			Coastal Shelf Fishing Pressure	Coastal Shelf Fishing Pressure				
			Fish Stocks Overexploited	Fish Stock Status	Fish Stock Status	Fish Stock Status	Fish Stock Status	Fish Stock Status
Issue Category on Air Pollution / Pollution Emissions / Acid Rain								
10	2.5	4.2	8.75			6	3	4
Regional Ozone	Ecosystem ozone	Ecosystem ozone						
Urban Particulates	SO ₂ emissions	SO ₂ emissions per populated land area	SO ₂ per capita			SO ₂ emissions	SO ₂ Growth Rate	SO ₂ Growth Rate
		NO _x emissions per populated land area				NO _x emissions	NO _x Growth Rate	NO _x Growth Rate
		Non-methane VOC emissions per populated land area						

2006	2008	2010	2012	2014	2016	2018	2023	2022
			SO ₂ per \$ GDP					
Issue Category on Agricultural								
3.33	2.5	4.2	5.83	2.5	10	3	3	4
Agricultural Subsidies	Agricultural subsidies	Agricultural subsidies	Agricultural subsidies	Agricultural subsidies				
	Pesticide regulation	Pesticide regulation	Pesticide regulation	Pesticide regulation				Sustainable Pesticide Use
	Intensive cropland							
	Burned Land Area							
	Irrigation Stress							
		Agricultural water intensity						
					Nitrogen Balance	Sustainable Nitrogen Manage. Index	Sustainable Nitrogen Manage. Index	Sustainable Nitrogen Manage. Index
					Nitrogen Use Efficiency			
Issue Category on Water Resources								
10	7.5	4.2	8.75	12.5	12.5	6	3	3
Nitrogen Loading								
Water Consumption			Change in Water Quantity					
	Water quality index	Water quality index		Wastewater Treatment	Wastewater Treatment	Wastewater Treatment	Wastewater Treatment	Wastewater Treatment

2006	2008	2010	2012	2014	2016	2018	2023	2022
	Water stress index	Water stress index						
		Water scarcity index						
Policy Objective on Ecosystem Vitality (2006 - 2020)								
Policy Objective on Climate Change (2022)								
Issue Category on Energy & Climate Change								
10	25	25	17.5	12.5	12.5	18	24	38
Energy Efficiency								
	Emissions per capita	GHG emissions per capita					GHG per Capita	GHG per Capita
	Emissions per electricity generation	CO ₂ emissions per electricity generation	CO ₂ per kWh	Trend in CO ₂ Emissions per kWh		CO ₂ Emissions Power		
		Industrial GHG emissions intensity					GHG Intensity Trend	GHG Intensity Trend
			CO ₂ per capita					
CO ₂ per GDP			CO ₂ per \$ GDP			CO ₂ Emissions Total	CO ₂ Growth Rate	CO ₂ Growth Rate
Renewable Energy			Renewable Electricity					
				Change of Trend in Carbon Intensity				

2006	2008	2010	2012	2014	2016	2018	2023	2022
					Trend in Carbon Intensity per kWh			
	Industrial carbon intensity			Trend in Carbon Intensity	Trend in Carbon Intensity			
							CO ₂ from Land Cover	CO ₂ from Land Cover
							F-gas Growth Rate	F-gas Growth Rate
						Methane Emissions	CH ₄ Growth Rate	CH ₄ Growth Rate
						N ₂ O Emissions	N ₂ O Growth Rate	N ₂ O Growth Rate
						Black Carbon Emissions	Black Carbon Growth Rate	Black Carbon Growth Rate
								Projected GHG emission 2050

Appendix B: Agencies and required detailed data from agencies for assessment of EPI+ and EPI Thailand

Agencies	Data	
	EPI+	EPI Thailand
Department of Provincial Administration	<ul style="list-style-type: none"> - Population - Population in districts of measurement station locations 	<ul style="list-style-type: none"> - Population - Population in districts of measurement station locations - Total households in Thailand
Department of Climate Change and Environment	<ul style="list-style-type: none"> - CO₂ emission growth rate - CH₄ emission growth rate - N₂O emission growth rate - F-gas emission growth rate - Greenhouse gas emission growth rate (excluding LULUCF) - SO₂ emission growth rate - NO_x emission growth rate - Emission-related data from agricultural biomass burning, forestry, land use and burning waste in incinerators (waste sector) - Growth rate in CO₂ emissions from land cover 	<ul style="list-style-type: none"> - CO₂ emission growth rate - CH₄ emission growth rate - N₂O emission growth rate - F-gas emission growth rate - Greenhouse gas emission growth rate (excluding LULUCF) - SO₂ emission growth rate - NO_x emission growth rate - Emission-related data from agricultural biomass burning, forestry, land use and burning waste in incinerators (waste sector) - Growth rate in CO₂ emissions from land cover
Community Development Department		<ul style="list-style-type: none"> - Number of households using village tap water throughout the year
Pollution Control Department (Air)	<ul style="list-style-type: none"> - NO_x concentration at measurement stations (annual average) - SO₂ concentration at measurement stations (annual average) - CO concentration at measurement stations (annual average) - Air quality standard in general atmosphere 	<ul style="list-style-type: none"> - PM_{2.5} concentration at measurement stations (annual average) - Ozone concentration at measurement stations (annual average) - NO₂ concentration at measurement stations (annual average) - SO₂ concentration at measurement stations (annual average) - CO concentration at measurement stations (annual average) - VOCs concentration at measurement stations (annual average) - Air quality standard in general atmosphere
Pollution Control Department (Garbage and waste)	<ul style="list-style-type: none"> - Amount of solid waste - Components of solid waste - Amount of controlled solid waste 	<ul style="list-style-type: none"> - Amount of solid waste - Components of solid waste - Amount of controlled solid waste
Pollution Control Department	<ul style="list-style-type: none"> - Total wastewater - Amount of treated wastewater 	<ul style="list-style-type: none"> - Total wastewater - Amount of treated wastewater

Agencies	Data	
	EPI+	EPI Thailand
(Water quality)	- Number of people access to wastewater treatment services	- Number of people access to wastewater treatment services - Number of surface water sources with at least moderate water quality
Department of Marine and Coastal Resources	- Marine protected areas and Thai waters	- Marine protected areas and Thai waters - Population of dugongs, Irrawaddy dolphins, Hawksbill turtles, Green turtles, Leatherback turtles and Olive Ridley turtles - Biosphere reserve (Ngao) (Total areas, areas in conservation areas) - Number of protected areas being evaluated for management effectiveness - Mangrove areas - Integrity of seagrass - Integrity of coral reefs - Quantity of debris released into the sea through major rivers at upper Gulf of Thailand
Department of Water Resources	- Wetland areas	- Wetland areas - Wetland areas with international importance
Department of Fisheries	- Quantity of catches of 5 groups of aquatic animals (pelagic fishes, demersal fishes, shrimps, crabs and squids) - Fish caught by trawling and dredging	- Quantity of catches of 5 groups of aquatic animals (pelagic fishes, demersal fishes, shrimps, crabs and squids) - Quantity of catches of demersal fishes, trash fishes, shrimps, crabs, squids, clams and small sized shrimps - Catch per unit of effort
Royal Forest Department	- Forest areas	- Forest areas - Thailand's Total areas (fixed value)
Land Development Department	- Grassland areas - Wetland areas	- Wetland areas
Department of Alternative Energy Development and Efficiency	- Fuel quantity from report of energy account/ Energy Balance of Thailand	- Fuel quantity from report of energy account/ Energy Balance of Thailand - Average energy generated from usage of household solid fuels in one year
Department of Agriculture	- Fertilizer use for each crop (fixed value)	- Fertilizer use for each crop (fixed value)
Department of Health		- Percentage of household tap water passing Department of Health's drinking water quality standard B.E. 2563

Agencies	Data	
	EPI+	EPI Thailand
Department of National Park, Wildlife and Plant Conservation	- Conservation areas	- Conservation areas - Biome areas with international importance - Number of protected areas being evaluated for management effectiveness - Population on endangered species (tiger population)
Metropolitan Waterworks Authority		- Number of households using water under residential type
Provincial Waterworks Authority		- Number of households using water under residential type
Bank of Thailand		- Exchange rate (Baht to one US dollar)
Thailand Institute of Scientific and Technological Research		- Biosphere reserve (Sakaerat) (Total areas, areas in conservation areas)
Office of the Cane and Sugar Board	- Cultivation area, harvested area and yield of each crop (sugarcane)	- Cultivation area, harvested area and yield of each crop (sugarcane)
Office of Natural Resources and Environmental Policy and Planning		- Number of protected areas being evaluated for management effectiveness
Office of the National Water Resources		- Water stress
Office of the Permanent Secretary, Ministry of Public Health		- Sickness rate from lead poisoning in all cases per 100,000 population of all age groups
International Health Policy Program	- Disability Adjust Life Year (DALYs) from unsafe sanitation - Disability Adjust Life Year (DALYs) from unsafe drinking water	- Disability Adjust Life Year (DALYs) from unsafe sanitation - Disability Adjust Life Year (DALYs) from unsafe drinking water
Office of Agricultural Economics	- Cultivation area, harvested area and yield of each crop	- Cultivation area, harvested area and yield of each crop
National Statistical Office		- Percentage of households using solid fuels in cooking - Percentage of households with hygienic toilets
Office of the National Economic and Social Development Council		- Gross Domestic Product-Chain Volume Measures (Reference year of 2002)

Appendix C: Order of the National Environment Board No. 2/2023 dated 3 February 2023
 Subject: Appointment of a Subcommittee for the Management of Thailand Environmental Performance Index

(Unofficial translation)

Order of the National Environment Board

No. 2/2023

Subject: Appointment of a Subcommittee for the Management of Thailand Environmental Performance Index

The National Environment Board in the 6th meeting of 2022 on 23 December 2022 resolved to appoint a Subcommittee for the Management of Thailand Environmental Performance Index with the determination to create efficient and systematic results, in line with the current context in the report preparation and driving of operations on Thailand Environmental Performance Index.

Based on the authority granted under Section 18 of the Enhancement and Conservation of National Environmental Quality Act B.E. 2535; Order of the Prime Minister's Office No. 239/2020 dated 13 August 2020 on Subject: Authority delegated to Deputy Prime Ministers and Prime Minister's Office Ministers to perform duty as chairman of the boards in accordance with the law; Prime Minister's Office regulation and resolution of the National Environment Board, this is the appointment of a Subcommittee for the Management of Thailand Environmental Performance Index. It has members and the duty and power as follows.

1. Members

- | | | |
|-----|---|----------|
| 1.1 | Permanent Secretary of the Ministry of Natural Resources and Environment | Chairman |
| 1.2 | Secretary-General of Office of the National Economic and Social Development Council or representative | Member |
| 1.3 | Secretary-General of Office of the National Water Resources or representative | Member |
| 1.4 | Secretary-General of Office of Agricultural Economics or representative | Member |
| 1.5 | Director-General of Department of Fisheries or representative | Member |
| 1.6 | Director-General of Land Development Department or representative | Member |
| 1.7 | Director-General of Pollution Control Department or representative | Member |

1.8 Director-General of Department of Marine and Coastal Resources or representative	Member
1.9 Director-General of Department of Water Resources or representative	Member
1.10 Director-General of Royal Forest Department or representative	Member
1.11 Director-General of Department of National Park, Wildlife and Plant Conservation or representative	Member
1.12 Director-General of Department of Alternative Energy Development and Efficiency or representative	Member
1.13 Director-General of Department of Provincial Administration or representative	Member
1.14 Director-General of Community Development Department or representative	Member
1.15 Director-General of Department of Disease Control or representative	Member
1.16 Director-General of Department of Health or representative	Member
1.17 Secretary-General of Office of the Cane and Sugar Board or representative	Member
1.18 Director of National Statistical Office or representative	Member
1.19 Governor of Thailand Institute of Scientific and Technological Research or representative	Member
1.20 Governor of Provincial Waterworks Authority or representative	Member
1.21 Governor of Metropolitan Waterworks Authority or representative	Member
1.22 Secretary-General of Office of Natural Resources and Environmental Policy and Planning	Member and Secretary
1.23 Director of Strategy and Planning Division Office of Natural Resources and Environmental Policy and Planning	Member and Assistant Secretary
1.24 Director of Policy and Planning Subdivision Strategy and Planning Division Office of Natural Resources and Environmental Policy and Planning	Member and Assistant Secretary

2. Responsibilities and authorities

2.1 Coordinate the operation and support information in the preparation of Thailand Environmental Performance Index for policy decision making as well as promote and support the execution of operations related to Thailand Environmental Performance Index.

2.2 Provide opinions and recommendations for the (draft) Thailand Management Plan of Environmental Performance Index

2.3 Regulate, monitor and assess the performance of Thailand Management Plan of the Environmental Performance Index as well as provide recommendations for solving problems and obstacles in the operations in accordance with the management plan.

2.4 Provide opinions and recommendations for the (draft) Thailand State of Environmental Performance Index report.

2.5 Appoint working groups as deemed appropriate for assigned operations.

2.6 Works in other areas as assigned by the National Environment Board.

The appointment shall come into effect immediately.

Issued on 3 February B.E. 2566 (2023)

(General Prawit Wongsuwan)

Deputy Prime Minister in his capacity as
Chairman of the National Environment Board